MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS

COMMUTER RAIL DESIGN STANDARDS MANUAL

VOLUME I
SECTION I

TRACK AND ROADWAY

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CHAPTER 1
INTRODUCTION

A. Background

The Commuter Rail Design Standards are a two-volume series that establish design objectives, guidelines, and criteria for commuter rail track and roadway, communications systems, signal systems and stations. Originally developed in 1976 as part of the Commuter Rail Improvement Program, this two-volume series expanded the Massachusetts Bay Transportation Authority's earlier series of design standards manuals for the rapid transit system--the Manual of Guidelines and Standards--to the area of commuter rail. This document contains extensive revisions and additions to the 1976 edition.

B. Purpose of the Manual

The purpose of this Manual is to provide guidance to the Authority and it's design consultants in commuter rail design and construction work. Due to the constant evolution of products and accumulation of practical experience it is neither practical or necessary to rigidly "standardize" all elements of the commuter rail system. The approach of this Manual is to recommend standardization of design criteria, but of components and material only when it is economically justified or is required for legal or technical reasons.

While the need for total system standardization is not a practical priority, it is a priority that future improvements satisfy all safety requirements and regulations regardless of methods or material used. The designer should also aim to achieve economy of design based on the past accumulation of prior experience with commuter rail improvements as well as consistency with the character and quality of the system's design.

This Manual is an important tool toward achieving the general goals of safety, economy, and consistency. In general, these standards establish three levels of guidance in the design of system improvements--design objectives, design guidelines, and design criteria and details. The design objectives are a very general form of guidance, broadly outlining the desired results of a component or facility.

Design guidelines are a more specific form of guidance. They describe the level of performance a facility should achieve; in general terms, where it should be located; what types of user or other needs it should satisfy; standard dimensions and clearances to be achieved; and where appropriate, several approaches to meeting the guidelines. In short, guidelines represent a planning and programming level of guidance.

The most detailed guidance provided in the Manual is categorized as design criteria and details. These criteria and details may describe specific construction methods or materials which the Authority requires the designer to use in specific circumstances. An example is the use of full depth rubber rubber crossing panels at most grade crossings. More often, however, the criteria describe specific materials or methods of construction simply because they have been successfully used in previous commuter rail facilities and are likely to be applicable and successful on future projects.

Within Section I of the Manual, Design Objectives and Guidelines are contained in one separate chapter. In Section II, Design Objectives and Guidelines are addressed in each chapter.

C. Organization of the Manual

The revised Manual is organized into two loose leaf volumes:

Volume 1. Section I - Track and Roadway. Section II - Stations and Parking
Volume 2. Signal & Communications

The two volume Manual is organized in a loose-leaf format for the reasons of flexibility and convenience. The passage of time and experience will require continuous modifications of the design guidelines and criteria presented in the Manual. The loose-leaf format provides the flexibility needed to insert new pages and delete outdated material. In addition, the format simplifies the process of copying pages or sections of the Manual as needed to guide future design work.

D. Revisions

The revision number and date of issue are noted in the revision box. When revisions are made, the entire chapter and a new table of contents is issued. By consulting the current table of contents, it is possible to determine if the chapters in the Manual are the latest revision. Any designer working on projects for Railroad Operations should check with the Authority to confirm that they are using the most recent revision before proceeding.

E. Other Applicable Documents

In addition to the Design Standards Manual, there are three other documents which supplement the Track and Roadway, Section I of the Manual. The first two are essential for designers to have and use with this document.

- Book of Standard Plans - Track and Roadway
- Railroad Operations - Commuter Rail - Material Specifications
- MW-1 Manual - Maintenance of Way Manual

CHAPTER 2
DESIGN OBJECTIVES / GUIDELINES

A. Design Objectives

The objective of the Design Standards Manual for Track and Roadway shall be to provide a safe, efficient, and reliable fixed plant for the operation of the Massachusetts Bay Transportation Authority (MBTA) commuter rail services as well as through and local freight service over MBTA rights-of-way.

The use of these design standards is required for new installations or when general renewal or replacement of track and roadway materials is to be undertaken. Requirements for maintenance of existing track and roadway elements are contained in the Authority's separate MW-1 (Maintenance-of-Way) Manual. The separate Book of Standard Plans - Track and Roadway shall be considered as an extension of this section of the manual and plans contained therein are cited in this document as appropriate. Material Specifications for track and roadway material are contained in the document titled Railroad Operations - Commuter Rail Material Specifications which are also cited in this document as appropriate.

Track and roadway design and installation practices not specifically addressed in this Manual shall be in accordance with the current American Railway Engineering Association (AREA) Manual of Recommended Practice and Portfolio of Trackwork Plans.

All designers/consultants preparing plans and specifications for any project for MBTA Railroad Operation's facilities shall be required to use this document and the separate Book of Standard Plans as a basis for design. Exceptions are the Northeast Corridor between Boston and the Rhode Island state line where the requirements of Amtrak will be followed and any work on the Worcester Line west of Framingham Station where the requirements of Conrail will be followed.

It is recognized that field conditions and special situations often occur and present circumstances that cannot be addressed in the Manual. In these instances, it is the designer's responsibility to bring this to the attention of the Authority and direction will be given by the Chief Engineering Officer, Railroad Operations for that specific instance. In all cases, issues of safety shall be the primary concern.

B. Design Guidelines

The MBTA commuter rail system extends over portions of three former Class I railroads. Each had its own standards for track and roadway materials, designs, and practices. Since acquiring these properties in the 1970's, changes and improvements have eliminated many of the differences but some still exist.

For all new installations of track and roadway and major rehabilitation projects, the design standards specified herein and related documents noted in Chapter 1, Part E, shall apply in the interest of uniformity of design and maintenance.

Track and roadway components which are renewed shall adhere to current MBTA Standard Plans and Material Specifications.

The following specific design guidelines and policies are basic to all track and roadway engineering design:

1. Safety - The primary purpose of all engineering design shall be to provide for the safe operation of trains and elimination of hazards to personnel and equipment. Application of standard design to all situations is rarely possible. The designer is responsible to recognize when deviation from standards will be necessary and call it to the attention of Railroad Operations. The designer and Railroad Operations will work together to arrive at a satisfactory solution with safety the primary concern.

2. Reliability - The design and choice of component materials shall be in accordance with MBTA Railroad Operations Standards, deviating only when specifically allowed by the Chief Engineering Officer, Railroad Operations.

3. Design Speed - Maximum design speed for commuter rail shall be 70 mph and 100 mph where directed. However, the design for 70 MPH should not preclude a future increase to 79 mph[1]. The present exception is the Northeast Corridor/Shore Line Main Line which will be up to 150 mph. Existing permanent operating speed restrictions shall be maintained unless a change is sanctioned by the Authority. Station areas are to be designed for maximum authorized speed of track in abutting territory to facilitate operation of express trains.

4. Clearances - Minimum horizontal and vertical clearances shall conform to those shown on Standard Plans 1012 to 1019. In general, new design shall provide 14'-0" track centers and 8'-6" side clearance with appropriate compensation for curvature. In no case shall new design provide less than 13'-0" track centers. Vertical clearances will be on a site specific basis. (See Chapter 6)

   For continuous adjacent structures greater than 100 feet in length, measured along the track base line and closer than 8'-6" to centerline of track, safety niches shall be provided. Such restricted clearance will require a variance from the Department of Public Utilities (DPU). Chapter 6 contains additional information on clearances.

5. Load Capacity - Track and roadway shall be designed to accommodate heavy freight train traffic. Track bridges and other structures shall be designed for Cooper E-80 loadings as prescribed in the AREA Manual.

6. Grade Separation and Grade Crossings - In general, new grade separation structures shall be provided wherever possible to eliminate crossings at grade. Existing and future public and private grade crossings shall

[1]79 MPH is the maximum speed allowed by Federal Railroad Administration (FRA) without cab signals.

be protected with flashers and gates approved by the Massachusetts Department of Public Utilities. Private crossings used less than two crossings of track(s) per week may instead use crossbucks and a locked right-of-way gate. Key for gate to be given to property owner and an agreement signed by owner that gate shall be kept locked except when they are in actual use of crossing.

7. New Grade Crossings - No new public grade crossings, auto or pedestrian, of main tracks shall be permitted without the permission of the Director of Railroad Operations, the local community, the County Commissioners and approval of the warning system by the Massachusetts Department of Public Utilities.

   No new private grade crossings shall be permitted without the expressed consent of the Director of Railroad Operations and subject to an agreement signed by the General Manager of the MBTA.

CHAPTER 3
GEOMETRIC DESIGN CRITERIA

A. Horizontal and Vertical Survey Control Requirements

Unless otherwise directed by the Chief Engineering Officer, Railroad Operations, the horizontal control used to establish rectangular coordinates for track geometry shall be based on the Massachusetts Plane Coordinate System, Mainland Zone. Horizontal control points and supporting survey shall meet U.S. Coast and Geodetic Survey second order specifications for accuracy with Class I requirements (1 part in 50,000) for projects encompassing more than 5 miles. Class II requirements (1 part in 20,000) will be adequate for projects less than 5 miles in length.

Vertical control shall be based on U.S. Coast and Geodetic Survey Mean Sea Level Datum, 1929 General Assessment. All vertical control points or benchmarks shall meet U.S. Coast and Geodetic Survey Second order Class II Specifications for accuracy. On small projects (less than 1 mile in length), third order requirements may be used.

B. Design Speeds

■ Design Speed	-	70* mph (100 mph where directed)[1] (*Do not preclude future increase to 79 mph)
■ Minimum Design Speed	-	Maximum speed allowed by local conditions
■ Station Pass-By Speed	-	Maximum authorized speed for territory[2]
■ Terminals, Terminal Approach Tracks and Servicing Areas[3]	- -	20 mph desirable 15 mph absolute minimum

C. Track Geometrics

1. General

The horizontal alignment of tracks shall consist of a series of tangents connected with circular and compound curves with appropriate spirals. Vertical alignment shall consist of tangent grades connected by parabolic vertical curves as required by these criteria.

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[1]On certain routes, such as Northeast Corridor and others where station spacing, geometry, etc. permit - design for up to 150 mph as directed.

[2]Up to 2-3/4" unbalanced elevation permitted in stations to achieve maximum speed so as to minimize actual elevation in station.

[3]Terminal areas include: Major stub end terminals, servicing areas, train storage yards and immediate approaches thereto.

2. Tangent Lengths - Horizontal

a. Mainline

Minimum desirable tangent lengths between reverse curves and/or spirals shall be 100 feet. In very limited areas where design speeds are 50 mph or less, tangents of lessor distance may be permitted with permission of Chief Engineering Officer, Commuter Rail and if spirals are long enough to provide less than a one half inch change in reverse cross level over 62 feet. Short tangents between curves in same direction (broken back curves) should be avoided by compounding to a flatter curve or using a connecting spiral.

b. Yards

In terminals and yard areas where design speed is 20 mph or less, tangent length may be reduced to 65 feet (the approximate truck spacing of an 85' long car) and, within yards only, when space is very limited and with permission of Chief Engineering Officer, the following table may be used:

	Degree of Reverse Curves	Minimum Recommended Tangent Length (Feet)
Less than	7° - 8°	20
	8° - 9°	25
	9° - 10°	30
	10° - 11°	40
	11° - 12°	50
	12° - 13°*	60

*Curves this sharp normally not permitted.

TABLE 3.1

C. Turnouts and Crossovers

The use of "back to back" turnouts of the same hand which results in a reverse curve, is prohibited unless a tangent length of at least 65 feet measured from PS to PS of the turnouts is added. Maintaining this dimension is especially critical with No. 8 & 10 turnouts. In yards and other low speed areas, the criteria indicated in Table 3.1 above may be used with permission. A No. 10 turnout has an equivalent radius of about 8° and a No. 8 about 12°-30'. It should be noted that a No. 8 crossover in track centers less than 14'=0" will not meet the criteria in the above table. No. 8 crossovers should therefor be avoided and used only with permission of the Chief Engineering Officer where absolutely necessary.

3. Curve Length

The minimum curve length (not counting connecting spirals) shall be 100 feet. In compound curves, each curve segment of differing radius should be at least 100 feet long.

4. Horizontal Geometry

a. Curve Definition

Curves shall be defined by chord definition and specified by degree. Arc definition shall not be used.

$$R=\frac{50}{Sin\ D/2} \quad or \quad Sin\ D/2 = \frac{50}{R} \quad or \quad D=2\ Sin^{-1}\frac{50}{R}$$

Formula 3.1

b. Maximum Curvature

The maximum degree of curvature allowed on main tracks is a function of design speed and the amount of superelevation - both actual elevation and unbalanced. Figure 3.1 illustrates the maximum curvature for a given design speed using both the preferred 1.5" as well as the maximum 2.75" unbalanced elevation combined with the maximum allowable 6" actual elevation. (See C.4.e. following for a discussion of superelevation)

Figure 3.1 based on following formulae from AREA:

$$E_a + E_u = 0.0007\ DV^2$$

(See 4.e following for derivation of this formula) Formula 3.2

$$V = \sqrt{\frac{E_a+E_u}{0.0007D}}$$

Formula 3.3

or

$$D=\frac{E_a+E_u}{0.0007\,V^2}$$

Formula 3.4

V = Velocity in mph
D = Degree of Curvature
Ea = Actual Superelevation in inches
Eu = Unbalanced elevation in inches

Figure 3.1 following uses the maximum allowable 6 inches actual elevation (E_a)

Design Speed - MPH	Max. Curve with 1.5" Eu	Max. Curve with 2.75" Eu
40	6°-42'	7°-49'
50	4°-17'	5°-00'
60	2°-59'	3°-28'
70	2°-11'	2°-33'
80 (79)	1°-43'	2°-00'
100	1°-04'	1°-15'

Figure 3.1

NOTE: Figure 3.1 will be modified if the FRA increases the currently mandated 3 inches maximum E_u to a higher value.

Within station platforms, the maximum curvature shall be limited to as flat a curve as possible. On platforms on the inside of curves, the curvature shall not exceed 4°-00' to control gap from door to platform edge.

Within yards and terminals, sharper curves are allowed. Due to rolling stock restrictions, maintenance considerations and historical experience, the preferred maximum curvature on any track regularly used by 85 foot long passenger equipment is 11°-00'. Any curvature in excess of 12°-00' should be avoided as operation above that radius has been found to be unreliable.

c. Design Considerations

Curvature, superelevation, spiral lengths and design speeds are all interrelated. The goal in design is to combine those elements in a way that provides a comfortable and safe operating speed for the predominant traffic. When designing a new or upgraded segment of railroad, the designer should avoid a curve by curve approach, blindly applying the criteria to each curve to achieve maximum possible speed. This may result in a curve with superelevation sufficient for 79 mph bracketed by curves limited to 50 mph. Because trains take a very long distance to change velocity, especially above 35-40 mph, trains will run the 79 mph potential curve at 50 mph. This will result in passengers sensing an inward lean on the curve and cause excessive wear on the inside rail.

The most restrictive curve in a given section of railroad sets the speed for that section. The designer should investigate various means by which the restrictive curve may be modified to increase the speed to that of adjacent lesser restrictions. The cost and other factors should be assessed with Railroad

Operations to determine what level of modifications could be justified or appropriate for each such location.

Signal aspects approaching interlockings may also be a factor in determining the line speed for a section of railroad. The designer should be aware of the locations of interlockings and inquire whether or not they will limit the maximum authorized speed for most trains in the approach area of the interlocking.

Often there are jurisdictional and safety issues that affect the design speed rather than civil restrictions based on geometry. An example would be a hazardous grade crossing which has a speed restriction imposed by the DPU.

Train performance calculation programs are a useful tool in analyzing line segments to determine what the practical maximum speed will be. By factoring in civil and jurisdictional restrictions and reviewing the results, it is possible to develop an overall design that will match the actual speed of most trains.

d. Concentric Curves in Multiple Tracks

In multiple track territory, when tracks follow the same general alignment, the tracks shall be concentric in curves. Track centers must be widened 2 inches per degree for curvature to maintain the equivalent tangent track center. The preferred method of increasing track centers is to lengthen the spirals of the inside track to a length where the spiral offset distance (p) relative to the outside track spiral (p) distance is increased by an amount equal to the required track center increase. The equivalent tangent track center is the nominal tangent track center for the route segment. When redesigning curves, strive to provide equivalent 14'-0" tangent track centers wherever possible, but in no case less than 13'-0".

e. Superelevation

Superelevation is expressed in terms of inches that the outside rail is raised above the level of the inside or low rail. Profile grade is always based on the low rail as superelevation is achieved by raising the outside rail relative to the inside rail.

There are three components to superelevation as used in railway design. It is essential that the use and relationship of these three components is understood.

$$E_e = E_a + E_u$$

(See following page for explanation of terms).

Ee = Equilibrium Elevation
Ea = Actual Elevation
Eu = Unbalanced Elevation

Equilibrium Elevation (Ee) is the amount of elevation required on a given curve at a given velocity for centrifical force to be in equilibrium. That is, the resultant of the overturning force caused by the angular acceleration is directed perpendicular to the centerline of the elevated or "banked" track. When a train traverses the curve at the equilibrium speed, passengers will feel no sideways force and there is no tendency for the inside wheels to lift and the carbody to roll. (Figure 3.2)

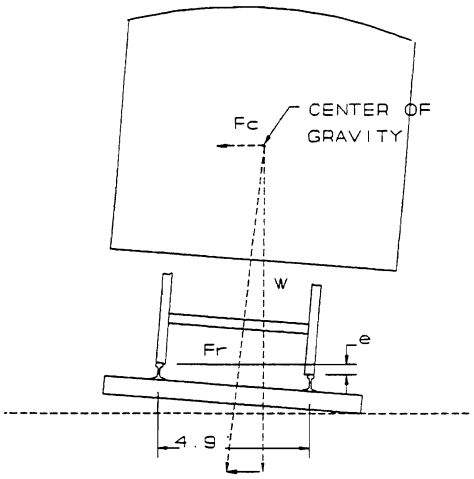


Figure 3.2

$$F_c = Wv^2/gR$$

Where:
Fc = Centrifical Force
W = Weight of car in lbs.
v = Speed in feet per second
g = Acceleration due to gravity (32.16 ft/sec/sec)
R = Radius of curve in feet
Fr = Resultant force of Fc & W directed perpendicular to elevated track
e = Equilibrium superelevation in inches

The formula derived from the proceeding used to determine equilibrium elevation on most passenger equipment is:

$$Ee = 0.000686\ DV^2 \text{ (usually rounded to)}$$
$$Ee = 0.0007\ DV^2 \qquad \text{Formula 3.5}$$
$$\text{Or}$$
$$Ee = 4.01V^2/R$$

Where:
- Ee = Equilibrium elevation in inches
- D = Degree of curve
- V = Velocity in mph
- R = Radius in feet

Unbalanced Elevation (Eu) is an equivalent amount of centrifical force which is not directed perpendicular into the track structure. A more descriptive term is cant deficiency. It has been found that a certain amount of deficiency in the elevation required for equilibrium is both safe and comfortable. For many years, the Federal Railroad Administration (FRA) has mandated that unbalanced elevation (cant deficiency) used in design and setting speed be limited to 3 inches for conventional passenger equipment. The MBTA currently uses a more conservative value for the amount of unbalanced (deficiency) elevation allowed, using 1.5 inches as the preferred limit and allowing up to 2.75 inches as a maximum. This provides improved passenger comfort, better compatibility with freight operations and a margin below the FRA mandated 3 inch maximum. Currently the 3 inch maximum Eu criteria is under review by FRA and an unbalanced elevation of 4 inches or more may be allowed in the future which would still provide a high level of safety and passenger comfort on well maintained track.

Actual Elevation (Ea) is the actual superelevation in track, limited to 6 inches. Based on the preceeding, the actual elevation required for a given curve is calculated as:

$$Ea = Ee - Eu$$
$$\text{or,}$$
$$Ea = 0.0007\ DV^2 - Eu \qquad \text{Formula 3.6}$$

Where:
- Ea = Actual Superelevation in inches
- D = Degree of Curvature
- V = Velocity in mph
- Eu = Unbalanced elevation in inches. (1.5 inches preferred, 2.75" max).

Minimum and Maximum Superelevation

Minimum Ea shall be 1 inch. Maximum Ea shall be 6 inches except it is desirable to limit Ea to 4 inches on routes where through freights operate and where trains are likely to stop or operate below the design speed on a regular basis. Within stations it is

desirable to limit Ea to 3 inches and use 2.75 inches Eu to allow express operation at maximum authorized speed.

Superelevation shall be developed uniformly through the length of transition spirals. Where spirals are not present or are of insufficient length, such deficiencies should be corrected as track is reconstructed. Running out of superelevation on tangents and curves is not permissable on medium to high speed routes and will be done only with permission of the Chief Engineering Officer. Proper spiral length is determined as discussed in the following sub-section.

Although calculated to the hundreth of an inch, actual superelevation in track is normally expressed and set in practice to the nearest one eight or one quarter inch.

f. Spirals

Spirals shall be used to connect all mainline curves to tangents. However, for practical considerations, spirals may be omitted when the required spiral length divided by the curve radius in feet is less than 0.01. Spirals shall also be used to connect compound curves whenever there is any change in Ea (actual elevation) or a change in Eu (unbalanced elevation) of 1/2 inch or more between the compound curves.

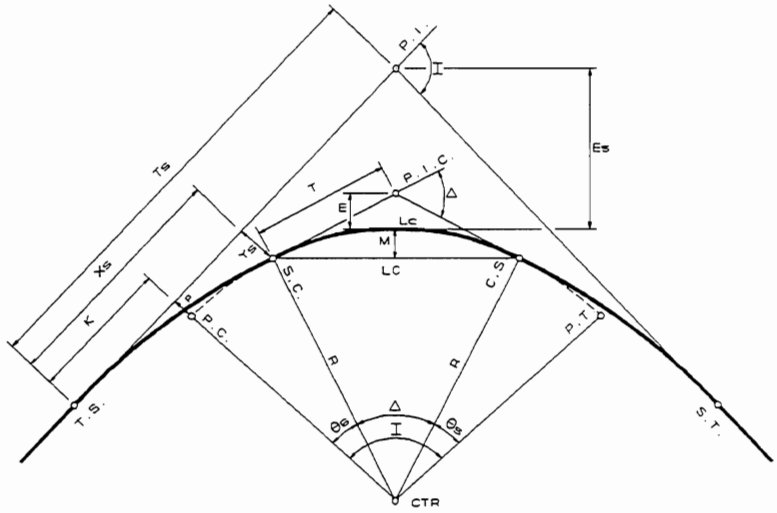
Spirals shall be a cubic parabola based on the so called "ten chord spiral" as shown in Figure 3.4. This is based on chord definition and is consistent with chord definition used with circular curves. The so called "Barnet Spiral", which is based on arc definition, will produce slightly different values.

Spirals shall increase in curvature directly with their length. Superelevation shall be increased uniformly over the length of the spiral reaching full Ea for the curve at the SC (spiral to curve point). The basic design data for spirals and curves is shown on Figures 3.3, 3.4 & 3.5.

In designing spirals and curves, determining the length of spiral (Ls) is a key element. There are three items that need consideration when determining the length of spiral:

1. The rate of run-in and run-out of the superelevation expressed in terms of inches per second, which affects passenger comfort.

2. The slope of the superelevated rail relative to the low rail. This results in a change in cross level between the two trucks of a car and should not exceed a 1 inch difference to prevent undue "racking" or torsional twisting of the car frame. This results in a tendency to lift the inside wheels of the lead truck. *Continuned on Page 3.12*



DEFINITIONS
Also See Figure 3.4

C.S.	CURVE SPIRAL, THE POINT OF CHANGE IN ALIGNMENT FROM CURVE TO SPIRAL
CTR	CENTER OF CIRCULAR CURVE
D_c	DEGREE OF CURVE DEFINED BY THE 100 FT. CHORD DEFINITION
E	EXTERNAL DISTANCE FROM MIDPOINT OF CIRCULAR CURVE FROM P.I.C
E_s	EXTERNAL DISTANCE FROM CURVE TO P.I.
I	ANGLE OF INTERSECTION OF MAIN TANGENTS AT P.I.
K	DISTANCE ALONG MAIN TANGENT FROM T.S. (OR S.T.) TO OFFSET P.C.
L	THE LENGTH OF EACH EQUAL CHORD
L_c	LENGTH OF CIRCULAR CURVE BETWEEN S.C. AND C.S. MEASURED ALONG 100 FT. CHORDS.
LC	CHORD LENGTH OF CIRCULAR CURVE FROM S.C. TO C.S.
L_s	THE LENGTH OF SPIRAL FROM T.S. TO S.C. (OR C.S. TO S.T.) AS MEASURED ON TEN CONSECUTIVE EQUAL CHORDS.
M	MID-ORDINATE DISTANCE OF CIRCULAR CURVE.
n	A NUMBER BETWEEN 1 AND 10 USED TO IDENTIFY CHORDS.
P	OFFSET FROM P.C. (OR P.T.) TO MAIN TANGENT.
P.C.	POINT OF CURVE, THE POINT OF CHANGE IN ALIGNMENT FROM TANGENT TO CIRCULAR CURVE, ON SPIRALLED CURVES THIS POINT IS OFFSET A DISTANCE P FROM THE MAIN TANGENT.
P.I.	POINT OF INTERSECTION OF MAIN TANGENTS.
P.I.C	POINT OF INTERSECTION OF LINES TANGENT AT S.C. AND C.S.
P.I.S.	POINT OF INTERSECTION OF MAIN TANGENT AND LINE TANGENT AT S.C. (OR C.S.)
P.T.	POINT OF TANGENCY, THE POINT OF CHANGE IN ALIGNMENT FROM CIRCULAR CURVE TO TANGENT, ON SPIRALLED CURVES THIS POINT IS OFFSET A DISTANCE P FROM THE MAIN TANGENT.
R	RADIUS OF CIRCULAR CURVE.
S.C.	SPIRAL CURVE, THE POINT OF CHANGE IN ALIGNMENT FROM SPIRAL TO CURVE.
S.T.	SPIRAL TANGENT, THE POINT OF CHANGE IN ALIGNMENT FROM SPIRAL TO TANGENT
T	DISTANCE FROM SC OR CS TO P.I.C. IN SPIRALED CURVE OR TANGENT FROM PC OR PT TO PI IN A SIMPLE CURVE
T.S.	TANGENT SPIRAL, THE POINT OF CHANGE IN ALIGNMENT FROM TANGENT TO SPIRAL.
Ts	LONG TANGENT, DISTANCE FROM P.I. TO T.S. (OR P.I. TO S.T.)
U	LONG TANGENT OF SPIRAL. DISTANCE FROM P.I.S. TO T.S. (OR P.I.S. TO S.T.)
V	SHORT TANGENT OF SPIRAL, DISTANCE FROM P.I.S. TO C.S. (OR P.I.S. TO S.C.)
Xn	DISTANCE ALONG A MAIN TANGENT FROM T.S. (OR S.T.) TO OFFSET CHORD POINT N.
Xs	DISTANCE ALONG MAIN TANGENT TO PERPENDICULAR OFFSET TO S.C. (OR C.S.)
Yn	OFFSET FROM CHORD POINT N TO MAIN TANGENT
Ys	PERPENDICULAR OFFSET FROM MAIN TANGENT TO C.S. (OR S.C.)
Θ_n	CHORD ANGLE, THE ANGLE BETWEEN THE MAIN TANGENT AND CHORD N.
Θ_s	SPIRAL ANGLE, CENTRAL ANGLE OF SPIRAL.
Δ	ANGLE OF INTERSECTION OF TANGENTS OF CIRCULAR CURVE ONLY

MAIN TANGENTS - THOSE LINES TANGENT TO ALIGNMENT AT T.S. AND S.T. WHICH INTERSECT AT P.I.

CURVE WITH SPIRALS AND DEFINITIONS
FIGURE 3.3

1. $D_c = 2\ ARCSIN\ \frac{50}{R}\quad R = \frac{50}{SIN\ D/2}$

2. $\Theta_s = \frac{L_s\ D_c}{200}$

3. $L = \frac{L_s}{10}$

4. $\Theta_n = \frac{3n^2-3n+1}{300}\ \Theta_s \quad n=1,\ldots10$

5. $X_n = L \sum_{n=1}^{N} COS\ \Theta_n \quad n=1,\ldots10$

6. $Y_n = L \sum_{n=1}^{N} SIN\ \Theta_n \quad n=1,\ldots10$

7. $X_s = X_{10}$

8. $Y_s = Y_{10}$

9. $P = Y_s - R(1-COS\ \Theta_s)$

10. $K = X_s - R\ SIN\ \Theta_s$

11. $U = X_s - \frac{Y_s}{TAN\ \Theta_s}$

12. $V = \frac{Y_s}{SIN\ \Theta_s}$

13. $\Delta = I-2\Theta_s$ *(WHEN BOTH SPIRALS ARE OF EQUAL LENGTH)*

14. $T = R\ TAN\frac{\Delta}{2}$

15. $L_c = 100\ \frac{\Delta}{D_c}$

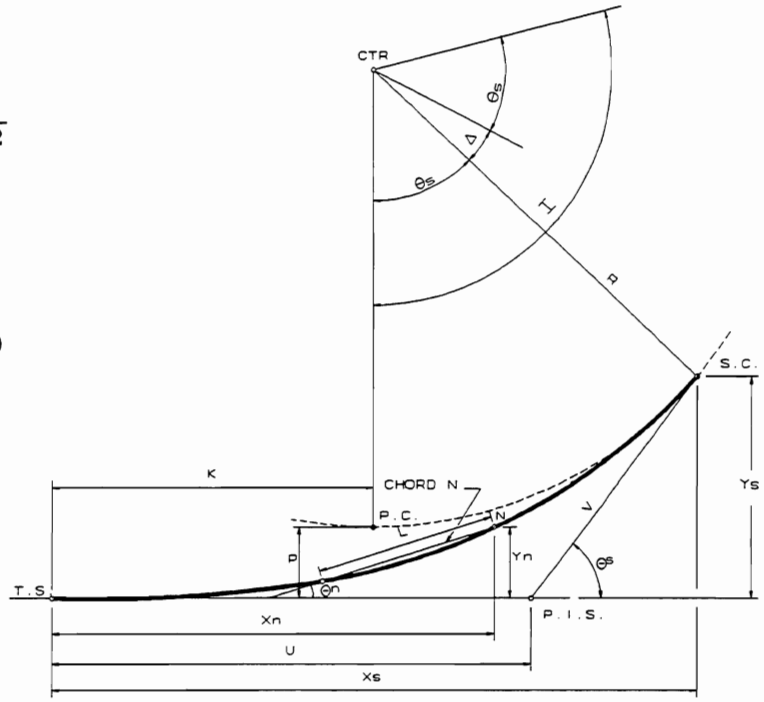
16. $E = R\left(\frac{1}{COS\frac{\Delta}{2}} - 1\right)$

17. $LC = 2R\ SIN\frac{\Delta}{2}$

18. $M = R\left(1-COS\frac{\Delta}{2}\right)$

19. $T_s = K+(R+P)\ TAN\ \frac{I}{2}$ *(WHEN BOTH SPIRALS ARE OF EQUAL LENGTH)*

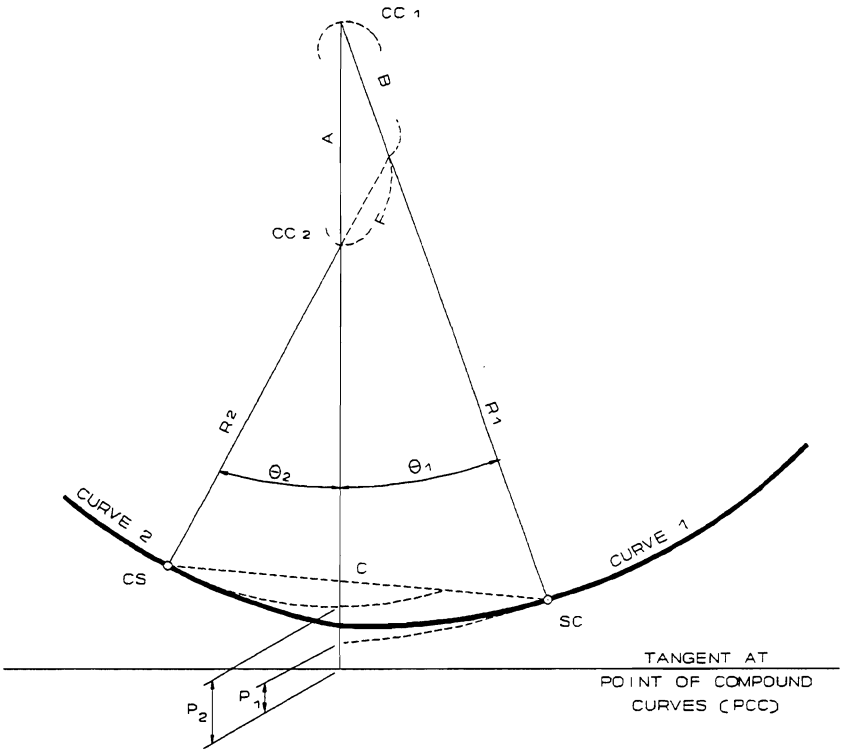
20. $E_s = \frac{T_s - K}{SIN\frac{I}{2}} - R$ *(WHEN BOTH SPIRALS ARE OF EQUAL LENGTH)*



NOTES:

1. Spiral criteria shown is for spirals between tangents and curves
2. For definitions, see Figure 3.3

SPIRAL AND RELATED FORMULAE
FIGURE 3.4



$$\Theta_1 = \frac{Dc_1 \times L_S}{200}$$

$$\Theta_2 = \frac{Dc_2 \times L_S}{200}$$

$$A = (R_1 - R_2) - (P_2 - P_1)$$

$$B = A\ SIN\ \Theta_2 / SIN\ (\Theta_1 + \Theta_2)$$

$$F = A\ SIN\ \Theta_1 / SIN\ (\Theta_1 + \Theta_2)$$

$$C^2 = (R_1 - B)^2 + (R_2 + F)^2 - 2(R_1 - B)(R_2 + F)\ COS(\Theta_1 + \Theta_2)$$

K = *RATE OF CHANGE IN DEGREE OF CURVE*

$$K = \frac{100\ (Dc_2 - Dc_1)}{LS}$$

$$P_n = Y_s - R(1 - COS\Theta_n)$$

COMPOUNDING SPIRAL
FIGURE 3.5

3. Lateral acceleration increase and decrease induced by the onset and then release of centrifical force caused by unbalanced superelevation when entering and leaving curves should be kept to low values for comfort. This acceleration rate is generally accepted to be 0.03 g/sec.

The first item (rate of superelevation run-in) is generally recommended to be 1-1/4 inches/sec for speeds up to 60 mph, 1-1/6 inches/sec from 60 to 80 mph and 1-1/8 inches/sec from 80 to 100+ mph. This can be expressed as:

Ls=1.17 Ea V (1-1/4"/sec)
Ls=1.26 Ea V (1-1/6"/sec)
Ls=1.30 Ea V (1-1/8"/sec)

The second item is a function of the truck spacing of an 85 foot long car. That dimension is typically 59'-6" for an 85' long car, however 62' is the figure used.

Ls=62 Ea

It has been normal practice to express elevation run-in in terms of inches per 31 foot chord (the usual stringlining interval). A run-in of 1/2 inch per 31' is typically used up to 50 mph and 3/8 inch per 31' from 50 to 80 mph and 1/4 inch per 31' from 80 to 100+ mph.

The following rates provide an expedient way of satisfying the first two items:

Ls=62 Ea Up to 50 mph
Ls=83 Ea 51 to 80 mph
Ls=124 Ea 81 to 110 mph

The third element - lateral acceleration increase - is expressed by the formula:

Ls=1.63 EuV (produces a lateral acceleration of 0.03g/sec)

In "tight" situations a shorter spiral is permitted:

Ls=1.22 EuV (produces a lateral acceleration of 0.04g/sec)

Summarizing: the minimum spiral length should be determined by using the longer result of the two following criteria:

1. Ls=62EaV $\leq$ 50 mph
   Ls=83Ea 50 < V $\geq$ 80 mph
   Ls=124Ea 80 < V $\geq$ 110 mph Formula 3.7

2. Ls=1.63 EuV (whenever possible)
   Ls=1.22 EuV (in "tight" situations) Formula 3.8

The minimum length of spiral shall be 100 feet in mainline track. A spiral of 62 feet is permitted in secondary track as a curve easement and when superelevation is not over one inch.

g. Gauge Widening in Curves

The MBTA does not normally widen track gauge in curves on commuter rail. However, in certain instances it may be beneficial to consider widening gauge 1/8" per degree of curve in excess of 10 degrees up to a maximum of 4'-9 1/8". This should be discussed with Railroad Operations on a site specific basis.

5. Vertical Alignment

a. General

Railroads are very sensitive to gradient due to very low power to weight ratios and frictional limitations imposed by the adhesion of steel to steel. For these reasons, as well as general safety and economy, grades must be kept to a minimum. Vertical curves connecting changes in gradient must be gradual, long enough to prevent coupler slack action run-in and run-out in long freight trains from generating forces great enough to break the couplers and separate the train or buckle the train. Passenger trains are normally not subject to slack-action problems. Operating at high speed, vertical curves need only to be long enough to prevent passenger discomfort caused by relatively small vertical g forces. However, good design dictates that more conservative values be used that will fit the available space, especially if through freight service is operated.

b. Maximum Grade

. Maximum Grade[4]	0.70% Preferred Max. 1.50% Absolute Max.
. Maximum Grade at Stations or any locations where trains may stop on a regular basis	0.50% Preferred Max. 0.75% Absolute Max.
. Maximum Grade at Maintenance Facilities & Unattended Storage Yards	0.00% Preferred Max. 0.25% Absolute Max.[5]

The ruling or maximum grades on a section of railroad must be compensated for the increased resistance caused by curvature by

[4]Under very special conditions a grade up to 3.00% is permissible with permission of the Chief Engineering Officer

[5]If steeper grades are required - derails and other protection from rolling should be considered.

reducing the grade through the curve by 0.04 percent per degree of curvature.

c. Minimum Length of Constant Grade

Frequent changes in gradient are to be avoided. Eliminate grade changes wherever physically and economically possible.

Minimum Length of Tangent Grade	200 Feet
Absolute Min. Length of Tangent Grade	75 Feet

d. Vertical Curve Length

The only generally recognized criteria used by railroads for 100 years in determining the length and corresponding rate of change of a vertical curve is in the AREA, Manual Chapter 5, Part 3, Section 13 which gives the required rate of change as 0.05 feet per 100' station in sags and 0.10 feet per station in summits. Up to twice that rate is possible in track of "lesser importance". This criteria is currently under review by AREA Committee 5 and it appears that a considerable reduction in the required vertical curve length recommended by AREA is forthcoming.

Experience has shown that application of the current AREA criteria in the MBTA's Commuter Rail Territory will often require vertical curves far too long to fit either existing or new conditions. The current AREA criteria's very low rate of grade change is to control the "accordion effect" that occurs in long freight trains which generally have about one foot of slack between each car. This slack is needed to start heavy trains as it would be impossible to start the entire train all at once. This slack creates adverse train handling conditions and high buffing and draft forces on undulating profiles with short vertical curves. These forces can contribute to breaking a train apart or buckling the cars. Considering only passenger equipment, which has little slack between cars and fewer units than a long freight, much shorter vertical curves would not affect train buffing and draft forces, the primary concern being passenger comfort. Even very slight gravitational ("g") forces in a vertical plane produce a "queasy" feeling in many passengers.

The following criteria is suggested in determining the minimum length of vertical curve in main track. This criteria is more conservative than the revised AREA criteria currently under consideration.

$$L=0.05\ (G_1-G_2)V^2$$ Formula 3.9

Where:

L	=	Length of vertical curve in feet.
G_1-G_2	=	Net or algebraic difference of the grade change in percent.
V	=	Velocity in mph.

AREA criteria currently under consideration:

$$L = 0.036\ (G_1-G_2)V^2$$

The rate of change in grade per 100 feet is the way the "sharpness" of vertical curves are usually expressed.

$$r=\frac{G_1-G_2}{L}x100$$ Formula 3.10

Where:

r=rate of change in %/100'

Following is a summary of various vertical curve criteria:

Current AREA Criteria	Rate of Change %/100'
(Double rates if necessary)	0.05% Sags 0.10% Summits

Northeast Corridor (Amtrak) criteria - 1970's

0.30%
Summits & Sags

"Suggested" MBTA criteria:

$$r = \frac{2000}{V^2}$$ Formula 3.11

(r not to exceed 0.80%/100')

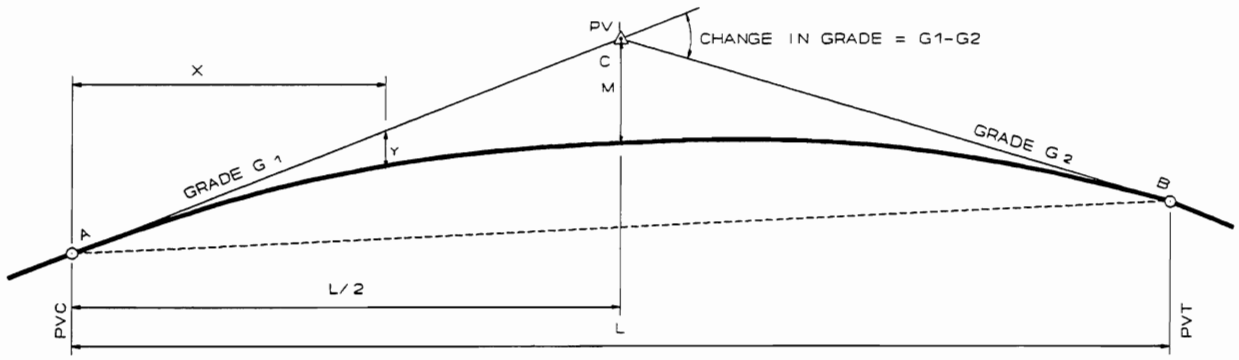
AREA Revision Under Consideration

$$r = \frac{2800}{V^2}$$

Formula 3.12

(r not to exceed 1.12%/100')

Unless otherwise directed, use Formulae 3.9 and 3.11, limiting rate of change to 0.80% per 100 feet. (Also see part "g" following).



Vertical Curves

Figure 3.6

Vertical curves shall be parabolic and have the following mathematical characteristics:

$$M = \frac{L/100\ (G_1 - G_2)}{8}$$

Formula 3.13

$$Y = \left(\frac{X}{L/2}\right)^2 x\ M$$

X cannot exceed L/2. Leftside of curve, use point A as origin for X. Right side of curve, use point B as origin for X.

Formula 3.14

$$L = \frac{G_1 - G_2}{r} x\ 100$$

Formula 3.15

$$Elevation\ of\ V.C.\ at\ any\ point = \left(\frac{r}{2}\right)\frac{x^2}{100} + G_1\ \frac{x}{100} + PVC\ Elev.$$

Formula 3.16

Where:

M = Mid ordinate of vertical curve at PVI
Y = Offset from tangent to vertical curve at any point on curve in feet
X = Any distance from PVC in feet
L = Length of vertical curve in feet
G_1 = Grade at PVC, in %
G_2 = Grade at PVT, in %
r = Rate of change in grade in %/100'

e. Vertical Curves Within Turnouts

It is good practice to avoid vertical curves in turnouts. When this is not possible, vertical curves may be introduced through turnouts with the following restrictions:

1. Keep vertical curves flat enough so that calculated vertical mid ordinate through the entire length of frog is 1/32 inch or less.

   This results in the following maximum permissible rates of change: Halve these rates in summit curves in switch area of turnout. This is in deference to concern that the switch points be forced upward - even slightly.

		Sag. Curves	Summit Curves
No. 8 T.O.	-	0.50%/Sta.	0.25%/Sta.
No. 10 T.O.	-	0.35%/Sta.	0.18%/Sta.
No. 15 T.O.	-	0.25%/Sta.	0.13%/Sta.
No. 20 T.O.	-	0.15%/Sta.	0.08%/Sta.

2. In yards or low speed areas where higher rates of change and shorter vertical curves may be necessary, vertical curves may be confined to the closure area of the turnout, the area between the switch and frog.

f. Minimum Length of Vertical Curve

Vertical curves shall not be less than 100 feet long on main lines. Curves with a calculated mid-ordinate less than 1/4 inch (0.021 feet) are too inconsequential to lay out in the field and maintain. Such vertical curves should be avoided by either lengthening the curve or using a vertical angle point when the algebraic difference of the grades is 0.10% or less.

Within yards and low speed areas such as servicing areas and

approaches to stub end terminals, vertical curves may be shorter than 100 feet and have rates of change in excess of 0.80%/100 feet, but never so short as to produce a vertical curve sharper than an equivalent radius[6] of 4,000 feet as determined by the formula:

$$Equivalent\ Radius^{6} = \frac{L}{G_1 - G_2} \times 100$$

Formula 3.17

Where:

L = Length of vertical curve in feet
G_1-G_2 = Difference in connected grades in percent

g. Combined Horizontal and Vertical Curvature

Another consideration in the design of both horizontal and vertical curves is the combined effect of "g" forces resulting when both horizontal and vertical curves are combined. The horizontal forces are discussed in Section 4 of this chapter and are related to lateral acceleration forces developed through the spiral and centrifical force from cant deficiency. Generally, the combined effect is not significant except when one or the other or both are at or near their maximum allowable value. In either case, the following check should be made and the design adjusted as required.

. In locations where horizontal curves are the controlling factor the rate of change of grade (r) which may be allowed to act concurrently shall be determined by the following formula:

$$r = \frac{2000}{V^2}(1-0.33Eu)(1-0.018Ee)$$

Formula 3.18

Where:

r = Rate of change of grade in percent/100' Station.
v = Velocity in mph.
Eu = Unbalanced Elevation of Horizontal Curve
Ee = Calculated Elevation for Equilibrium.
D = Curvature in Degrees

. In locations where vertical curves are the controlling

[6]Note that "equivalent radius" formula calculates a circular curve, not parabolic as an actual vertical curve is. Parabolic curve is flatter on both ends and somewhat sharper opposite the PVI than equivalent radius curve. Formula 3.17 provides an expedient way of determining relative sharpness of vertical curves.

factor, the unbalanced superelevation Eu allowed to act concurrently shall be determined by the following formula:

$$Eu = (3.00)\left(1-\frac{Iv^2}{2000(1-0.0000126V^2D)}\right)$$

Formula 3.19

Note: If a negative number is produced by above formula, either V or r must be reduced until a positive number is obtained.

This combined effect is not an issue with current AREA vertical curve criteria. Whenever the "suggested" criteria or "currently under consideration" AREA criteria is used, the combined horizontal/vertical effect should be investigated, and adjusted accordingly per above formulae.

CHAPTER 4
TRACKWORK CRITERIA

A. General

All track materials and special trackwork shall conform to the current MBTA "BOOK OF STANDARD PLANS - TRACK AND ROADWAY" and the "MATERIAL SPECIFICATIONS" which are referenced as appropriate.

All new installations or track renewals shall be with resilient fasteners on either timber or concrete ties as directed by the Chief Engineering Officer.

Ballasted track construction will be used at all locations except on bridges, viaducts, subways and tunnels, where direct fixation track construction may be used when directed by the Chief Engineering Officer.

New open deck bridges shall not be permitted except on a temporary basis. Existing open deck bridges shall be rebuilt to ballasted deck or direct fixation wherever possible.

Main track subgrade shall be designed to the dimensional requirements of Standard Plans 1000 and 1002 and as defined in Chapter 5 of this Manual.

B. Rail

Reference Material Specifications No. 9233 & 9236.
Reference Standard Plans - 1300 & 1302.

The standard MBTA rail section for new construction is 132 RE continuous welded rail. 115 RE CWR may be used in certain applications only when directed by the Chief Engineering Officer. Suitable, available fit relay rail sections, either CWR or bolted, may be used when replacing secondary tracks as and when approved by Railroad Operations.

Standard control cooled rail shall be used on all main line track with curves up to and including 2°-00'. Fully heat treated rail shall be used on all main line curves where curvature is in excess of 2°-00'. Carry heat treated rail through spirals and through tangents between adjacent curves over 2°-00' wherever the tangent is less than 300 feet long.

Fully heat treated rail shall not be used in curves outside of main lines, unless specifically directed.

Fully heat treated rail shall be used within all turnouts and other special trackwork units.

All rail shall be weldable by either electric flash-butt or thermite process.

C. Timber Cross Ties

Reference Standard Plans - 1100, 1104, 1106 and 1108
Reference Material Specification - 9209

Transition ties shall be used in areas of changing track modulus as shown on Standard Plan 1108.

Timber cross ties shall be spaced at 19-1/2 inches except use 18 inches within grade crossings. Within full depth rubber crossings, 9'-0" long ties shall be used.

Material specifications, seasoning and other requirements to be as specified in No. 9209.

D. Concrete Ties

Reference Standard Plan - 1120

Concrete tie are increasingly being used on the MBTA system. Use on a specific route/project shall be determined by the Chief Engineering Officer. Standard tie spacing for concrete ties is 24".

E. Subballast

Reference Standard Plans - 1000 & 1002
Reference Material Specification - 9251

Subballast shall be used on all new track construction or major reconstruction when the underlying material is not clean, free draining, well graded, granular material. The typical section shown on the standard plans should be considered adequate only for fair to moderately good subgrade conditions. If there is a history or direct evidence of difficulty in maintaining good surface and line at an existing track location or, if on new location, test borings indicate any condition other than good, granular material; the designer should recommend measures to provide adequate support for the track structure, including a change from the 8 inch depth of sub-ballast shown on the typical sections. Additional discussion of subgrade treatments is found in Chapter 5, Roadway Criteria.

F. Ballast

Reference Standard Plan - 1000 & 1002
Reference Material Specification - 9248

Crushed stone ballast per the referenced material specification shall be used on all trackwork. 12 inches depth under bottom of tie is the mainline standard. Ballasted deck bridges should also have 12 inches of ballast under the tie with 8 inches minimum when conditions warrant and when approved by the Chief Engineering Officer.

Maintenance of adequate ballast shoulders of 18" beyond the end of tie and good ballast compaction is essential to track stability and to control track buckling. All projects involving track reconstruction or realignment of track must provide construction specifications and phasing plans which both enforce and enable the proper preparation and compaction of the ballast section prior to opening track to service.

G. Tie Plates

Reference Standard Plans 1220, 1222, 1224 & 1225
Reference Material Specifications - 9269 & 9272

Tie Plates shall be used on all tracks regardless of use.

The MBTA standard for new timber tie track construction is resilient fastener plates with lock spikes. Within turnouts - either with tropical hardwood or treated oak - plates shall be fastened with screw spikes.

Cut spike tie plates shall not be used on new construction or track renewal projects unless specifically directed by the Chief Engineering Officer.

H. Spiking

Reference Standard Plans - 1104 & 1230
Reference Material Specifications - 9274 & 9275

Spiking patterns within standard timber and ballasted track construction shall be as per Standard Plan 1104. Within turnouts, screw spikes shall be used throughout as follows:

Gage Plates	-	6 screw spikes per plate
Shoulder Slide Plates	-	4 screw spikes per plate
Adjustable Brace Slide Plates	-	4 screw spikes per plate
Heel Plates	-	4 screw spikes per tie per plate.
Frog Tie Plates/Self Aligning Shoulder Plates	-	2 screw spikes per plate
All Standard Plates within Turnout	-	4 screw spikes per plate
Guard Rail	-	4 screw spikes per tie per guard plus 2 drive screw spikes per rail seat.

Holes for lock spikes shall be pre-drilled 9/16" dia. x 6" deep and 11/16" dia. x 6" deep for screw spikes. Holes not used, shall be plugged with treated or cedar tie plugs. Within turnouts using tropical hardwoods, pre-drill spike holes at gauge side of both switch points to allow spiking switch out of service with a cut spike. Plug such holes with cork tie plugs.

I. Rail Anchoring

Reference Standard Plan - 1232
Reference Material Specifications - 9239 & 9242

Anchoring patterns shown on Plan 1232 are for cut spike fastened tracks only. Track using the standard resilient fasteners does not require additional anchoring unless specified by the Chief Engineering Officer.

J. Resilient Fasteners

Reference Material Specification - 9245

Resilient fasteners and matching tie plates shall be used on all new installations and track renewal projects. In addtion to the standard plate used on timber ties and rag stem inserts, tie pads and insulators used on concrete ties, there are other systems to be considered in certain applications. These applications include direct fixation slabs and possibly open deck bridges. Impact attenuating, composite tie plates with provision for holding the rial with the standard resilient fastener are a system to be considered where appropriate.

K. Special Trackwork

Reference Standard Plans 2000 to 2499
Reference Standard Specifications - 9278, 9281, 9284 & 9287

Unless otherwise directed, use "floating heel block" design turnouts as detailed on the Standard Plans.

No. 20 turnouts shall be used for mainline crossovers and junctions of diverging mainlines wherever there is sufficient room. Allowable design speed for the Standard No. 20 turnout is 45 mph through the curved side of turnout. No. 20 equilateral turnouts may be used at ends of double track and such locations where they may be used to advantage. Allowable design speed through both legs of a No. 20 equilateral turnout is 65 mph (2.75 inches unbalanced elev.). With authorization of the Chief Engineering Officer, a speed of 70 mph may be used (3 inches unbalanced elev.).

No. 15 turnouts shall be used for mainline crossovers where there is insufficient room for No. 20's or where the design speed is limited to 30 mph or less because of other civil restrictions. No. 15 turnouts shall also be used to connect secondary lines and primary yard leads to the main line. Allowable design speed for the standard No. 15 turnout is 30 mph through the curved side of the turnout. No. 15 equilateral turnouts may be used where feasible. Allowable design speed through both legs of a number 15 equilateral is 50 mph (2.75 inches unbalanced elev.)

No. 10 turnouts shall be used for all sidetrack connections to the main line and all yard leads and yard tracks wherever possible. The No. 10 turnout is the preferred minimum size turnout for any commuter rail application. The maximum allowable design speed through the curved side of the standard No. 10 turnout is 20 mph, however, 15 mph is the preferred maximum for safety and maintenance considerations.

No. 8 turnouts shall be used only within yards and servicing facilities, only when it is physically impractical to fit No. 10's and only with permission of the Chief Engineering Officer. The maximum allowable design speed through the curved side of the Standard No. 8 turnout is 15 mph, however, 10 mph is the preferred maximum for safety and maintenance considerations.

Turnouts shall have 5 inch hot mix asphalt underlayment installed per MBTA Standard Plan No. 1030 and as indicated in Chapter 6, Section A4.

L. Switch Stands

Reference Standard Plans - 3020, 3023 & 3030
Reference Material Specification - 9257

Manual switch stands on mainline turnouts shall be intermediate height-model Racor 17D or New Century 50-B with operating rod sufficient to provide required side clearance and mounted on 16'-0" long headblock timbers. Electric lock is required on any installation in signal territory. Racor moded 17D or New Century 50-B shall also be used in yards where there is sufficient room for the 16'-0" headblocks.

Low stands - Racor model 36D or New Century Model 50A - shall only be used in yards and terminals where there is limited side clearance. Do not use in main track without specific authorization of the Chief Engineering Officer.

The Racor Style 22 is a "run through" type mechanism allowing automatic operation of trailing point movements through either leg of the turnout regardless of switch position. Use only in yards and servicing areas as directed by the Chief Engineering Officer.

All switch stands shall be furnished with the MBTA Standard Red/Green switch stand target unless specifically directed otherwise.

M. Bumping Posts

Reference Standard Plan - 3010
Reference Standard Specification - 9206

A steel, model "WA" bumping post per referenced standards shall be installed on all stub end tracks subject to operation (either revenue or non-revenue) by commuter rail equipment. Tracks used only for dead storage or work equipment storage may have other types of bunters. End of line stub end terminals will have energy absorbing impact attenuators capable of disapating energy equivalent to a nine car & one locomotive consist travelling at 10 mph. This requirement may be waived by the Chief Engineering Officer at locations where there is insufficient room and/or there are no buildings or structures in the path of a train which overshoots the end of track.

N. Emergency Guard Rails

Reference Standard Plans - 3060 & 3062
Reference Material Specification - None

1. Bridges

Guard rails (double rail) shall be used on all through girder and through truss bridges regardless of the span length and on any bridge when the structure length between abutment backwalls is over 40 feet.

Resiliently fastened guard rail as detailed on Standard Plan 3062 shall be used on all ballasted deck bridges and approaches and ballasted approaches to open deck bridges to aid in removal and reinstallation during surfacing operations.

The 39'-0" end approach section shall be lengthened at design speeds in excess of 60 mph as follows:

Length of guard rail end approach = 0.74V

V = design speed in mph.

2. Other hazardous locations

Single rail guard rails and/or crash walls may be used at such other locations where a derailment would cause significant structural damage to adjacent, vulnerable structures or to the railroad's equipment. Examples where such installations may be considered include:

a. Adjacent to steep drop-offs to water or where derailment would cause significant damage from the length of potential fall.

b. Adjacent to near-by high voltage structures.

c. Adjacent to any supporting column of an overhead bridge or structure which if struck by a train would very likely cause catastrophic failure of the structure. A crash wall may be appropriate in such cases. See Section "N" below.

O. Crash Walls

When tracks are immediately adjacent to supports for bridges, buildings and air rights development over the right-of-way, consideration must be given to protecting supporting structures from impact of a train in event of derailment.

The impact design loading for crash walls shall be as follows:

- Train weight, 1,666,000 lbs consisting of locomotive at 280,000 lbs and nine coaches-fully loaded at 154,000 lbs each.
- The angle of attack (measured from tangent to the track) shall be ten degrees.
- The impact speed shall be authorized track speed at the location plus a 50 percent safety factor.
- Place piers and abutments at such an angle that a square hit is not possible. Provide "wing" or angled section to deflect train away from blunt ends.

Refer to AREA Manual Chapter 8 for additional considerations with respect to crash walls.

P. Derails

Reference Standard Plans - 3000, 3004, 3006 & 3007
Reference Material Specifications - 9215

Split switch derails shall be used on all side tracks which connect to the main line with a descending grade.

Where less positive protection is required, sliding block derails may be used as directed by the Chief Engineering Officer.

Hinged block type derails shall be used only on engine house ready and storage tracks when power operated derails and interlocked blue flag protection is not available.

Derails used to protect main lines in signal territory must include circuit controllers, insulated joints and connections to signal system. If necessary, provide for sign installation - "Siding not to be used to clear main line".

CHAPTER 5
ROADWAY CRITERIA

A. SUBGRADE

1. General

The trackbed cross section will be designed to the dimensional requirements of Standard Plans 1000 & 1002. The minimum subgrade cross slope should be 1/4 inch per foot to facilitate the removal of water from under the track structure. Final subgrade elevation in either cuts or fills shall be set to allow placement of design trackbed section at design profile grade. The section shown on the Standard Plans will be used only when existing subgrade conditions are satisfactory. Design of trackbed section in poor subgrades and design of additional measures to provide a stable and maintainable track structure shall be responsibility of the designer.

At existing track locations, when track renewal is planned, the designer must investigate the following to determine the need for additional subgrade preparation.

a. Inspect track structure and note any areas with obvious problems such as muddy, fouled or pumping track, poor surface and alignment, wet conditions, instability in slopes supporting or above the trackbed, gullying or potential washouts, ditches and pipes filled or partially filled with silt or clay and trees or other vegetation which could undermine track bed if dislodged.

b. Interview maintenance personnel to determine any locations that are difficult to maintain or have a known history of stability or drainage problems.

c. Recommend and observe cross track test pits at any locations suspected of poor subgrade conditions.

d. Recommend and observe a soils boring program as required for any locations where a major subgrade problem is suspected.

At new track alignment locations, test borings, test pits or other suitable means should be included as a part of the design process to determine the nature and depth of soil strata that will be supporting and draining the track bed.

Hot mix asphalt underlayment shall be installed under all new turnouts and grade crossings per Standard Plans. Composition of mix shall be as indicated in Part 4 of this heading of "Subgrade".

2. Fill Sections

New fill foundations must be explored and then designed to prevent failure of the subsoil or excessive settlement. The exploration program should be developed and carried out as detailed in the AREA Manual - Chapter 1, Part 1.1. Use of sand or wick drains and

surcharging may be necessary to consolidate compressive soils prior to final construction.

When widening existing fills, benching the existing slope and placing new fill in compacted lifts not over two to three feet in depth must be detailed in the plans and specifications. Simply dumping material down the slope is not permissible except for shallow fills (less than 5 feet high) or when dumping stone rip-rap for erosion control. Existing culverts, including equalizing culverts, should be investigated, protected or extended as necessary prior to widening fill sections.

3. Cut Sections

Cut sections pose particular problems related to drainage and soil stability. Within existing cuts it is imperative that the side ditches be cleaned, enlarged and lowered to a depth not less than four foot six inches below top of rail. Ditches should also be graded to drain. Where ditches of sufficient depth and cross section are not possible, underdrains and closed drainage systems must be provided.

Visually inspect all cut slopes for signs of instability and excessive moisture which could lead to instability. If widening of cut slopes is indicated, investigate stability of slope and recommend construction methods and materials necessary to maintain slope stability. Top of cuts must be inspected for water retention or ponding areas caused by low points, beaver dams, etc. and methods to remove water away from the cut detailed.

The track bed within existing cuts often is composed of non-granular material which fouls ballast quickly and does not allow water to drain. This condition should be remedied as much as possible during track renewal projects. Excavation of unsuitable material, additional underdrains, placement of hot mix asphalt underlayment, geotextiles, are some of the methods that may be considered in various combinations to improve roadbed stability and lower the cost of maintenance.

4. Hot Mix Asphalt Underlayment

Hot mix asphalt underlayment (HMA) shall be installed as subgrade under roadway crossings and turnouts as shown on Standard Plans 1030, 3100, 3106 and 3108. HMA may also be installed under normal track where subgrade conditions are poor.

The recommended job mix formula for HMA underlayment shall be as specified in MBTA Standard Specification 02513, Table 02513-c supplemented by the following table:

Standard Sieves	Underlayment Mix (HMA)
2"	
1-1/2"	100
1"	90 - 100
3/4"	
1/2"	56 - 80
3/8"	
No. 4	29 - 59
8	19 - 45
16	
30	
50	5 - 17
100	
200	1 - 7
Bitumen	3 - 9

Table 5.1

HMA mix shall be installed in one course using sufficient material to provide a compacted mat 5 inches thick.

B. DRAINAGE

1. General

Drainage in stations and landscapped areas is also discussed in Section II, Chapter 6, Landscapping.

Good drainage and it's maintenance are absolutely essential to the safe and economical operation of a railroad. Safety is of paramount concern and certain drainage related problems can result in failure of either the roadbed or structures. During the design of both new facilities and reconstruction of existing, it is essential that close attention be paid to roadbed drainage, cross culverts and structures over water courses.

In designing for removal of surface and groundwater from the trackbed section, the following general conditions shall apply:

- Existing drainage patterns shall be maintained wherever possible.
- To the maximum extent possible, surface and subsurface drainage of the roadbed should be handled by a system of gravity - flowing longitudinal ditches that feed into catch basins, transverse ditches or streams. Ditches should be designed to handle anticipated flows without silting or scouring.
- Low points in ditches should be avoided but when required, positive means of removal of water must be supplied at the low points. Those means may include tieing into municipal storm

sewer systems by use of catch basins, leaching basins or groundwater recharge ponds (if permitted by subsurface geology and local ordinances), transverse ditches, culverts and natural or artificial watercourses.

- When absolutely necessary, where gravity outfalls are impractical, pumps may be considered to ensure positive drainage. In such instances, the design flow shall include an allowance for groundwater infiltration as appropriate.

- Drainage systems that discharge to an existing wetland or are within 100 feet of a wetland must comply with the rules and regulations of the Wetlands Protection Act and local bylaws. The local conservation commission must be contacted and informed of project details and probable wetland impacts. The commissions issue "Orders of Conditions" which should be incorporated into the design. Conservation commissions may also require an EIR or EIS.

- Drainage systems connecting to an existing storm drain must also comply with the Wetlands Protection Act if it discharges to a wetland. Approval is also required from the drainage system owner. The owner should be contacted early in the design process to determine their specific requirements.

2. Mainline Trackbed Drainage Criteria

   a. Do not drain subgrade from one track across or towards an adjacent track. The area occupied by each track should drain to its own ditch or subdrain.

   b. Do not drain areas from beyond the track bed through the track structure. Typically, a ditch or subdrain should lie between the track and the adjacent ground area to intercept fines from an adjacent slope which would foul the ballast.

   c. At locations where there will be a future track, crown the subgrade on the centerline between the tracks. Where practical, keep the ditch or subdrain on the field side of the future track clear of the future track so it doesn't have to be changed later.

   d. Typical drainage pattern for double track roadbed section is from a crown between the tracks to a ditch or subdrain on the field side of the tracks. When double track is between walls a single subdrain may be located between the tracks. "Walls" may include a retained cut or a retained fill where the walls are too close to the tracks to allow ditches or subdrains.

   e. Typical drainage pattern for single track is a crown line on the centerline of the track to ditches or subdrains on each side. When a single track is between walls, the ditch or subdrain may

be located on one side and the subgrade sloped in one direction to the ditch or underdrain.

f. At side platform stations, the platform should drain away from the track. A subdrain should be placed between the track and the platform to drain half of the track bed, and any water from platform canopies or areas behind the platform that are not handled by other site drainage. If there is a wall on the opposite side of the track from the platform, the entire track area should drain to the subdrain lying between the track and platform.

g. At island platforms, the platform should drain into the track area to avoid ponding at the center of the platform. Subdrains should be placed between track and platform so that track drainage is handled the same way as at a side platform station.

3. Design Considerations

a. Design Storm Computation

1. Rational Equation:

Design flows for local drainage shall be computed by the Rational Equation:

$$Q = CIA \qquad \text{Formula 5.1}$$

where:

Q = Runoff quantity, in cfs
C = Coefficient of Runoff
I = Rainfall intensity, inches/hour
A = Drainage area, in acres

2. Design Frequency:

The track drainage system including all open track bed areas exposed to direct precipitation shall be designed to accommodate the peak flows produced by the 50 year rainfall event. All runoff shall be fully contained within the drainage system, no surcharge will be allowed for undepressed catch basins and the capacity of all pipes, ditches, etc. shall equal or exceed the 50 year runoff. In addition, the storm drainage system shall be designed to maintain a maximum water level 18" below top of tie during the 100 year rainfall event.

The drainage systems for non mainline track areas such as parking lots, station accessways and layover facilities shall be designed to accommodate flows produced by a 10-year storm unless otherwise specified by regulatory authorities. The capacity of the receiving storm-drain system shall be investigated to determine if there is adequate capacity to comply with this requirement.

3. Time of Concentration:

The minimum time of concentration used shall be 5 minutes.

Time of Concentration shall be determined by the equation:

$$Tc = (0.0078\ K\ L^{0.77})/S^{0.385}$$ [1] Formula 5.2

Where:

Tc = Time of Concentration, minutes
L = Maximum length of Travel from most remote point in drainage basin to outlet, feet
S = Average slope (feet/foot) = H/L
H = Difference in elevation between most remote point and drainage outlet
K = 1.0 for natural basins with well defined channels, for overland flow on bare earth, and for mowed grass roadway channels.
K = 2.0 for overland flow over grass surfaces
K = 0.4 for overland flow, concrete or asphalt surfaces
K = 0.2 for concrete channel

For areas with abrupt changes in topography or surface, the calculation shall be done for each segment and the total time of concentration shall be arrived at by adding the computed values for each segment.

4. Rainfall Intensity:

Rainfall intensity shall be obtained for specific design storm frequencies and times of concentration by using the Rainfall intensity-Duration-Frequency Curve for Boston, Massachusetts, as found in Technical Paper No. 25 of the U.S. Department of Commerce, Weather Bureau, December, 1966 on Rainfall Intensity-Duration-Frequency Curves.

[1] This equation is based on a study by Z.P. Kirpich (1940)

5. Coefficient of Runoff:

Values of runoff coefficient for use in the Rational equation (Q = CIA) shall be as defined in ASCE Manual No. 37, Design and Construction of Sanitary and Storm Sewers or Table 1 on Page 53 of Design of Roadside Drainage Channels, Hydraulic Design Series No. 4, U.S. Department of Commerce, Bureau of Public Roads, May, 1965.

b. Ditches

1. Geometric Requirements:

Ditches shall be of trapezoidal section, with a minimum depth of 18 inches and a minimum bottom width of 2 feet. They shall have a minimum gradient of 0.25% and a maximum design velocity of 2 feet/second for unlined channels. Water levels in ditches at design flow rates shall be at least 3 feet below the top of rail.

2. Flow Computation:

Drainage velocities and capacities shall be computed by use of Manning's Equation:

$$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$ Formula 5.3

where:

V = Velocity, ft/sec
n = Manning's Coefficient of Roughness
R = Hydraulic Radius, feet
= area/wetted perimeter
S = Slope, feet/foot

Manning's "n" values shall be determined from ASCE Manual No. 37 or Table 2, Page 53-54 of Design of Roadside Drainage Channels, Hydraulic Design Series No. 4, U.S. Department of Commerce, Bureau of Public Roads, May, 1965.

3. Gutter Flows and Inlets

Where curbing is proposed along roadways, gutter flows and gutter inlets shall be designed in accordance with the U.S. DOT - Federal Highway Administration Hydraulic Engineering Circular No. 12, Drainage of Highway Pavements, March, 1984. At least 10' of the travel way shall be free of gutter flows.

c. STORM DRAINS

1. Material, Cover and Structural Requirements:

Either reinforced concrete or asphalt-coated corrugated metal pipes shall be used. Minimum diameter pipe size shall be 12 inches. Culverts shall have a minimum diameter of 18 inches.

Pipes under railroad tracks shall be designed for Cooper E80 loading and shall have a minimum cover of 2 feet from bottom of tie to top of pipe.

Pipes under highways, parking lots and driveways shall be designed for H20 loading. They shall have a minimum cover of 1 foot from top of pavement to top of pipe.

2. Flow:

Manning's Equation, as defined in the ditch section and as shown below, shall be used.

$$Q = \frac{0.463 D^{\frac{8}{3}} S^{\frac{1}{2}}}{n}$$ Formula 5.4

Where:

full capacity

S = Pipe slope feet/foot)
Q = Flow (cubic feet per second)
n = Manning's roughness coefficient (Feet $^{1/6}$)
D = Pipe diameter (feet)

Pipes shall be designed for uniform flow, with a preferred velocity in the range of 3 to 9 feet per second. Maximum headwater for culverts shall be 1-1/2 times the pipe diameter. At design flows, water shall not back up at the pipe entrance to an elevation higher than six inches below top of railroad subgrade or roadway pavement.

No pipe shall be designed with a size smaller than the next pipe upstream.

3. Manholes:

Manholes shall be installed at all pipe junctions and grade or alignment change points. Maximum pipe length between manholes shall be 300 feet.

4. Catch Basins:

Catch basins shall be installed at all ground or pavement surface low points and all grades not drained by ditches or other means. The maximum interval between catch basins shall be 300 feet.

Catch basins shall have a 30 inch deep sump and a cast iron hood, frame and grate. Bicycle safe grates shall be used in station access roads, parking lots, and other areas where bicycle traffic is possible. Design of catch basins, cover and general arrangement must be done in a way to allow cleanout of sump with a clam shell bucket.

If leaching catch basins are used, they shall have a minimum of 12 inches of 2 inch diameter crushed stone placed around the outside. Their design shall be based on "perc" test data taken at the basin site. The design leaching capacity of the basin shall be increased to allow for partial blockage by debris and fine sediment.

d. Perforated Pipe Drains

Where ditches are not permitted by space, where additional flow capacity is needed, or where required to reduce underground hydrostatic pressure, perforated pipe drains shall be used. The pipes shall be perforated bituminous coated galvanized corrugated metal or perforated PVC. Minimum size shall be eight inch diameter in grade crossing installations and 12 inch diameter when used in place of ditches.

Where perforated pipes are used only as underdrains to reduce underground hydrostatic pressure and control groundwater elevation, the perforations shall face down. Where perforated pipes are being used to carry water with groundwater control a secondary requirement, the pipe shall be laid with perforations up. Use of perforated pipes to carry water shall be limited to the upper runs of a drainage system and checked to ascertain that they will not be subject to surcharging. Separate carrier pipes, for storm drainage shall be used in combination with perforated pipe underdrains in most cases.

Filters shall be used with all perforated pipe drains to prevent accumulation of sediment in the pipes. Filter material may consist of suitably graded crushed stone, synthetic filter material, or a combination thereof. The filter envelope shall extend a minimum of eight inches beyond the outside diameter of the pipe.

Perforated pipe drains shall discharge to a gravity drainage system or pump station. Care shall be taken to ensure that perforated pipe drains are not blocked by high water levels at

the outlet. Relatively impervious materials such as loam or topsoil shall not be installed vertically above these pipe drains.

MHWA design gas traps or oil-water separators shall be provided in areas where runoff is subject to contamination with petroleum products and where required by regulatory authorities.

e. Recharge and Detention Ponds

1. Detention Ponds

Detention Ponds shall be designed when necessary to limit peak outflow from the design storm to an acceptable value. When these detention ponds discharge into a wetland a review by the local conservation commission is required. The detention ponds shall include provisions for removing sediment, if warranted. Each pond must be evaluated individually to determine if enough sediment will enter to justify a sedimentation basin.

Ponds shall be provided with an emergency overflow section to allow the safe discharge of water in excess of the design storm. Multiple outlets may be used when needed to accommodate maximum and minimum design storms. Required storage volume shall be determined using inflow and outflow hydrographs based on the Soil Conservation Service criteria or another approved method.

2. Recharge Basins

Recharge basins shall be designed with both a sedimentation basin section and a recharge basin section. The sedimentation basin shall be designed to remove all sediment that might plug the pores and reduce the basin's infiltration capacity.

The recharge basin section shall be designed to allow infiltration of the design storm within a reasonable period of time. The recharge basin capacity may be supplemented using recharge wells or trenches if necessary. The infiltration capacity shall be based on percolation field tests. Deep hole field tests shall be used to determine the depth to ground water and/or the location of impervious strata.

The combined storage capacity of the recharge and sedimentation basins shall be adequate to contain the runoff from the design storm. The basins shall have an emergency overflow to allow the safe discharge of water in excess of the design storm.

f. Sedimentation and Erosion Control

1. Grading

Cut and fill slopes shall be as flat as practical. Minimum slopes shall be adequate to provide positive drainage. Mowed lawns shall have a 1% minimum slope and unmowed lawns or areas with groundcover shall have a minimum slope of 2%. Maximum mowable slopes shall not exceed 3:1 horizontal to vertical with an unmowable maximum slope of 2:1. Slopes steeper than 2:1 will require geotextile, rock or other protection treatments. The tops and toes of all slopes shall be rounded.

Roadways and parking areas shall be graded in accordance with the station and parking section of the Manual contained in Volume II.

2. Diversion Channels:

Diversion channels shall be located at the top of all steep cut slopes where terrain rises away from the track centerline. They shall be designed in accordance with the requirements of this chapter. Diversion channels shall discharge to the storm drainage system or a natural water course. Diversion channel outlets shall be designed to minimize erosion. All discharges into existing wetlands or within 100 feet of such shall comply with the rules and regulations of the local conservation commission.

3. Grade Stabilization Structure:

When it is necessary to convey storm water from one level to another across a steep slope, a grade stabilization structure shall be used. It may be a lined chute, drop box culvert, pipe drop inlet, channel with check dams, or other suitable structure.

4. Vegetation and Revegetation:

Grading operations shall minimize disturbance of existing vegetation. The design shall allow staged construction whenever practical to minimize the exposure of bare earth and the resulting sedimentation. Erosion control matting shall be used when necessary to avoid erosion of slopes before new vegetation can become established.

Vegetation requirements shall be coordinated by a landscape architect with the MBTA and each respective municipality.

5. Local Requirements

Whenever work takes place in a wetland area or within the buffer zone, the local conservation commission must be contacted, a notice of intent filed if required, and any orders of conditions issued incorporated into the design. Conservation commissions typically will require control of sedimentation and erosion during construction. Appropriate measures such as silt fences, straw bale checks, staged construction, and revegetation requirements shall be incorporated into the design.

C. FENCING

1. General

Fencing is a critical element of the commuter rail physical plant. Fencing provides safety for the general public, protects passengers using our facilities and the operation of both the Authority's trains as well as the freight carriers. Fences perform various functions in a wide variety of locations. Selection of the proper size and type of fence as well as it's proper installation is important. No trespassing signs shall be attached to all gates and on fences, facing in both directions, at intervals not exceeding 200 feet and as detailed on Standard Plans.

2. Types of Fences

Reference Standard Plans - No. 3200, 3204, 3206 and 3208.

The primary fence type is chain link at heights of 48 inch, 72 inch, 96 inch and 120 inch. The three strand barbed wire top is an option on all chain link fence.

High Security Fence consists of a very dense, close-spaced, difficult to climb mesh fabric with closer post spacing.

At overhead bridges, special mounting details are required. Also, special fence details using posts and fabric that curve back over the bridge to prevent throwing objects, (anti-missile fencing) at trains may be necessary at high risk locations.

Gates may be single swing, double swing or sliding as appropriate for the location, size of opening and use. In all cases, the design of the gate and related hardware must be of the heaviest, most durable material available to provide reliable operation over the life of the installation.

Snow fences are usually a portable type installed seasonally by maintenance forces. Treated timber fences of permanent construction may be used for this purpose and/or as a view block in areas where snow

drifting is a regular problem and where a visually solid fence would not be objectional.

3. Uses of Fences

a. Right-of-Way Fence

Fencing along the Authority's right-of-way is used to prevent unauthorized entry as well as to define the property of the Authority and abutters. The size and exact type of fence to use at a specific location is a function of the existing and potential degree of trespassing at that location. The following is a general guideline arranged in ascending order of control of trespassing:

. Very rural-wooded	No fence
. Rural-fields or farmland	72" CLF
. Light Suburban	72" CLF
. Medium to Dense Suburban	72" CLF with B/W
. Urban	96" CLF with B/W
. Urban areas with severe trespassing problems	96" HS-CLF with B/W

B/W = Barbed wire top-3 strands
HS = High Security Type fence

Gates must be located at suitable sites and frequency to allow maintenance personnel access to the right-of-way. This is especially critical at interlockings.

At a specific location, where trespassing has been a problem, a short segment of a more restrictive fence may be installed than used in the balance of the installation.

b. On-Site Access Control

Fences may be used at stations and parking areas to control where and how people move about. This is generally for their safety but may also be a means of directing them to the areas intended. In most situations, 48 inch CLF is appropriate for this purpose. Intertrack Fence is a particular use of this type of fence and is detailed on Standard Plan No. 3204. Its installation details and lack of a top rail is unique to that use. (See Station Design Section of Manual also.)

c. Snow Fences

Reference Standard Plan - 3200

Drifting snow caused by prevailing winds from the direction of open areas and accumulation of snow in cuts can be a problem for maintenance forces and have adverse affects on train operations,

station platforms, parking areas and access roads. Installation of snow fences is usually seasonal using portable type fences. In certain instances, it may be appropriate to use a permanent fence such as the "Wood Open Board Fence" shown on Standard Plan 3200. Landscape plantings of evergreens may also be effective barriers to use on a permanent basis where fences may be inappropriate.

d. Overhead Bridges

Overhead bridges, both vehicular and pedestrian, pose problems related to debris being thrown and dropped on the right-of-way and trains. Anti-missile fencing may be used as a barrier in these locations with special curved posts and extra wide fabric utilized at locations where vandalism is prevalent. Fan guards or short cantilever fence sections may be helpful at the ends of fence on bridge approaches.

e. Fence Setback from Property Lines

In most cases, right-of-way fences shall be installed 12 inches from the actual property or ROW line and on Authority property. Where clearances are close and where directed, this dimension may be reduced to 6 inches.

D. RIGHT-OF-WAY SIGNS, POSTS AND MARKERS

Reference Standard Plans 3300 to 3399

1. General

Various signs, both informational and regulatory, are required around any railroad. During reconstruction or new installation of right-of-way facilities, replacement, reinstallation and furnishing new signs shall be considered an integral part of the project. Specific signs related to stations and parking facilities are <u>not</u> covered in this section. These signs are covered in Section II, Stations and Parking.

Right-of-Way signs generally fall into two categories - informational and regulatory. Informational signs include:

- Mileposts
- Close Clearance Warnings
- Yard Limits
- Flanger Warning Boards

Regulatory signs include:

- Speed Boards - Permanent and Temporary
- Whistle Posts

2. Lettering shall be Helvetica Medium with certain applications in condensed form. Exceptions to the above only with direction from the Chief Engineering Officer. Letters shall be black gloss silk screen conforming to Mass Highway Department (MHD) material spec. M7.04.12 or reflectorized press-on vinyl equal to black "Scotchal".

3. Background shall be reflectorized white paint meeting Federal Specification FSL-S-300 A type, Class 1 or 2, reflectivity 1 for mileposts and no trespassing signs.

   Other signs with colored background shall use an adhesive vinyl covering as follows:

   . Yellow - No. 2271 Yellow Scotchlite
   . Green - No. 2277 Green Scotchlite
   . Silver - No. 2870 Silver Scotchlite

4. Sign boards shall be made from 0.081 inch thick aluminum alloy 6061-T6. Mile posts shall have a 1/4 inch thick steel sign back behind each sign panel as per Standard Plan 3302. Other permanent signs shall also include a 1/4 inch thick steel sign back when scrap rail sections are used as a post. Steel board to be welded to base of rail along both edges.

   Aluminum sign boards shall be mounted to steel sign back with a minimum of four 5/16 inch x 1 inch bolts with lock nuts and washers, all cadmium plated.

   Steel sign backs shall be cleaned with a grease cutting solvent, primed and painted with two coats of white enamel prior to mounting sign boards.

5. Sign posts for free standing, permanent signs are preferred to be fabricated from used rail sections at least 112 lb section, free from bends, kinks or visible damage. Rails shall be cleaned with a grease cutting solvent, primed and painted with two coats of white enamel after welding on steel sign boards.

   Temporary signs or small (18 inch x 24 inch or less) signs may use steel "U" posts or square posts pre-drilled for mounting. Posts shall have 1/4 inch thick anchor plates attached per detail on Standard Plan 3306.

   Any sign post which could be struck by a motor vehicle shall include a break-away mounting.

6. Sign locations

   a. General - The designer shall coordinate required signage and location with Railroad Operations. In general, the following signs and markers are required.

b. Mileposts - Are located based on mileage from the primary terminal (North or South Station) and are located to the right of the outbound track with the mileage signs facing in both directions. Miles should be based on the original railroad stationing whenever possible.

If the existing mileposts are made of granite and are in good condition, they may be repainted (white) on top and lettering redone (black) and reused instead of the rail post mile marker.

c. Permanent speed boards shall be placed at every point where there is a change in the authorized speed and at least every two miles.

d. Yard limit signs shall be placed at yard limits facing both inward and outward tracks at locations where there are defined yard limits. Yard limit locations should be checked with Railroad Operations. Yard limits are normally defined by the carrier operating freight service, not by the Authority.

e. Whistle posts shall be located 1000 feet in advance of location for which locomotive whistle is to be sounded.

f. Ring post shall be at location where locomotive bell ringing is to commence and repeated every 1000 feet where prolonged ringing is required.

g. Crossing circuit sign shall be placed at start of grade crossing protection circuit. On bi-directional tracks (signalled for movement in either direction), signs shall be provided on both approaches to the crossing. When crossings are close together and the crossing circuits overlap, signs shall also include small letters to indicate the crossing number (in mileage from terminal) of the respective crossing. Signs shall be placed directly opposite the insulated joints concerned.

h. Stop posts shall be used to indicate a grade crossing for which no protection is provided or for a crossing where a full stop must be made before activating the protection. Sign shall be placed 25 feet in advance of the crossing or opposite the insulated joint.

CHAPTER 6
CLEARANCE CRITERIA

Reference Standard Plans - 1012 to 1019

A. General

Providing and maintaining adequate horizontal and vertical clearance is a key element in the safe operation of a railroad. Existing clearances on many routes in the Authority's territory are sub-standard by today's requirements due to the age of the facilities. During reconstruction and renewal, improvements in clearance that can be achieved are a priority item.

To the extent possible, new facilities or major rehabilitation and reconstruction shall conform to current Commonwealth of Massachusetts Statutes for clearance within yard limits. These statutes require a 22'-6" vertical clearance above top of rail, 8'-6" to any side obstruction from centerline of track and 13'-0" track centers with suitable increases for curvature. Various exceptions to the above are noted on the referenced standard plans and discussed in more detail below.

B. Vertical Clearances

1. Background

Vertical clearance within yard limits is defined by state statute as 22'-6" above top of rail. Yard limits were or are defined by the freight carriers, not by the MBTA. Historically, the requirement for 22'-6" clearance is based on protecting personnel walking on top of a box car that typically was about 15'-6" high. This is now a prohibited practice, roof walks are no longer placed on cars and brake wheels have been moved from the top of cars to a height just above the coupler.

Today, freight carriers are very concerned with improving clearances so they can remain competitive and handle cars which are considerably taller than the 14' to 15-1/2' box car of previous times. Fully enclosed tri-level automobile carriers and double-stack containers (shipping containers stacked two high on special drop-well flat cars) require a clearance just under 21 feet.

The MBTA has an interest in providing sufficient clearance for future electrification. This will be practical if the 22'-6" dimension is used and would be possible for passenger operation and very limited freight operation with 18'-0" clearance.

2. Minimum Vertical Clearance

When and if 22'-6" is not possible, lesser clearance will be permissible. Standard Plan 1016 gives the minimum vertical clearance by route segment which will satisfy both the MBTA's and current freight carrier's requirements. These clearances are subject to frequent revision due to changing requirements of freight carriers. Designers must check with railroad operations before design is advanced.

The absolute minimum clearance that is required to clear equipment of the MBTA and allow for dynamic movement plus a nominal safety factor and minimal resurfacing raise is 16'-4". Any clearances between 16'-4" and those indicated on Standard Plan 1016 must be approved by the Chief Engineering Officer.

3. Compensation for Superelevation

If tracks are superelevated under an overhead structure, clearance must be increased to allow the required vertical clearance out to a point 7'-0" from centerline of track on a plane even with the top of rail of superelevated track. (See sketch on Standard Plan 1016).

Relative to the low rail, which is the profile grade line, the required increase is defined by the following formula:

Increased clearance in inches = 1.43 x Ea

Formula 6.1

Where:

Ea = Actual Superelevation in Inches

4. Compensation for Vertical Curves

When there are vertical curves at overhead obstructions, allowance must be made for the vertical mid-ordinate of a car up to 90 feet long.

$$Increased\ clearance = \frac{0.90\ x\ G_1 - G_2}{8}$$

Formula 6.2

Where:

G_1 = Grade at PVC in percent
G_2 = Grade at PVT in percent

C. Horizontal Clearances

1. Background

By state statute, horizontal clearance within yard limits is 8'-6" from centerline of track from a plane at the top of rail vertically upward to the vertical clearance restriction. Yard limits were or are defined by the freight carriers, not the MBTA. The reason for 8'-6" is to allow a brakeman riding the side of a car to clear any obstructions. 8'-6" also provides room for a train to clear someone standing along side. The exception to the above is switch stands and other individual obstructions necessary for the operation of the railroad which are less than 3'-0" above top of rail. The reasoning being that a man riding the side of a car will be over that height and because they are only

point obstructions, a pedestrian would not get trapped between it and a train.

Although 8'-6" side clearance is dictated only within yard limits, it is imperative that this clearance be maintained everywhere possible for safety. Where 8'-6" side clearance cannot be maintained, safety niches must be provided and warning signs posted. (See Part E following).

2. Allowable Exceptions to 8'-6" Side Clearance.

Due to operational and physical requirements, certain elements, under certain conditions may intrude into the 8'-6" tangent clearance envelope as follows:

a. Low switch stands and electric locks less than 3'-0" above top of rail may be 6'-6" from centerline.

b. Low passenger platforms (less than 8" above top of rail) may be 5'-1" from centerline.

c. High passenger platforms (4'-0" above top of rail) may be 5'-7" from centerline. On certain routes, a breakaway, foldup edge to allow 7'-3" for over-dimension freight movements shall be provided. (See Article 5, following). At major terminals with direct fixation track and no freight operation, 5'-4" may be used.

d. Intertrack fence at passenger stations may be 6'-0" from track centerline if fence is not more than 4'-0" high. (See Standard Plan 3204).

e. Top flange of through plate girder bridges less than 4'-0" above top of rail may be closer than 8'-6" as shown on Standard Plan 1017 and with the conditions indicated in the asterisk note (*) on that plan.

f. Dwarf signals outside of track to be 7'-6" from centerline. Dwarf signals between multiple tracks permitted only if not over 2'-0" above top of rail.

g. Platform canopies may be 7'-6" from centerline of track except on Framingham/Worcester Line, maintain 8'-6".

3. Side Clearance Increase for Superelevation

All side clearances must be increased on the inside or low side of curves to compensate for the inward lean of equipment. The formula used for this purpose is:

$$\textit{Increased side clearance in inches} = h/5 \times Ea$$

Formula 6.3

Where:

h = Height of obstruction above top of rail in feet.
Ea = Actual superelevation in inches.

4. Side Clearance Increase for Curvature

Side clearances must be increased for curvature on both the inside and outside of curves. This is to maintain equivalent tangent clearance which would otherwise be decreased due to end overhang of the car on the outside of curves and mid-ordinate swing-in on the inside of curves.

Side clearance increase, both inside and outside of curves, shall be 1 inch per degree of curvature. Exception - at passenger platforms, on the outside or high side of curves, side clearance shall be increased only one half inch per degree. At platforms, clearances for curvature in excess of two degrees and in excess of one inch actual superelevation shall be reviewed by the Chief Engineering officer. (See Standard Plan 1019).

5. Special Side Clearance at High Platforms for Freight Operations

On certain routes shared by through freight operations, the 5'-7" side clearance to high platforms is not always sufficient for all types of freight equipment under all operating conditions. Provision must be made for providing 7'-3" side clearance on an occassional basis by swinging the platform edges up and locking in a vertical position. This will allow passage of over-dimension equipment. In addition, the outer 9 inches of the platform must be made of a material that will shatter and the supports swing out of the way when accidently struck.

Special details for this type of platform edge have been previously developed and are available from Railroad Operations.

All high level platforms in territory where through freight service operates shall have the collapsible edge. The fold-up edge or other means such as a gauntlet track to allow 7'-3" side clearance, must be provided on the following routes or segments thereof.

NORTHSIDE

West Route - Wilmington Junction to State line
New Hampshire Main Line - Boston to State Line
Wildcat - Wilmington to Wilmington Junction
Fitchburg Main line - Willows to Fitchburg

SOUTHSIDE

Framingham (B&A) Main Line - Beacon Park to Worcester
Middleboro Secondary - Braintree to Middleboro
Franklin Branch - Walpole to Readville

6. Side Clearance - Special Issues

The designer should always be diligent in looking for and checking points that have or will have substandard side clearance. Even on tangents adjacent to curves, it should be remembered that car overhang resulting from curvature extends the full length of the car into the tangent.

High platforms pose especially critical clearance concerns, particularly when curvature is involved and freight operations use the track. All elements affecting clearance including curvature, superelevation, vehicle outlines and dynamic movement must be considered.

D. Track Centers

1. Standard Track Center Dimension

The standard track centers for tangent main line track effective the date of issue of this standard is 14'-0". Track centers of 13'-0" are permissable on an interim basis at such locations where 14'-0" is currently not possible.

The standard track centers for tangent main line track to an adjacent track used as a yard or switching lead, where personnel may be standing or walking in the space between the tracks, is 17'-0".

2. Track Center Increase for Curvature

Track centers must be increased at the rate of 2 inches per degree of curvature to allow for both end overhang and mid ordinate swing-in on adjacent, concentric tracks. It is essential that equivalent tangent track centers be maintained on curves. The equivalent tangent track center is the nominal tangent track center for the route segment. When re-designing curves, strive to provide equivalent 14'-0" tangent tracks centers wherever possible, but in no case less than 13'-0".

3. Absolute Minimum Track Centers

No commuter rail operations will be permitted on track centers less than 11'-8" on tangent. Track centers must be increased above 11'-8" for curvature and check that adjacent tracks have the same superelevation. No new construction will be allowed at 11'-8" track centers except temporary layouts during phased construction when absolutely necessary.

4. Track Center Increase For Unequal Superelevation

When the outer track has more actual superelevation than the inner track, increase the track center dimension 3 1/2 inches per inch of superelevation difference. This is in addition to the 2 inches per degree for curvature.

5. Concentric Curves in Multiple Track

In curved multiple track, the tracks shall be concentric unless the curve is being used to spread tracks for a center platform, bridge pier, etc. Track centers providing less than 14'-0" equivalent tangent clearance shall be spread at 2 inches per degree on the curve. Transition back to standard tangent centers within the spirals by increasing the length of spirals on the inside track to a length such that the spiral offset (p) is increased over that of the outside track spiral by an amount equal to the track center increase.

E. Safety Niches

1. Where Required

Safety niches shall be provided at all locations where side clearances from center line of track on both sides of the track bed are less than 8'-6" over a total distance along the track in excess of 100 feet.

2. Dimensional Requirement

Safety niches shall be no less than 7'-0" high by 2'-0" wide. The base or floor of the niche shall be not more than 8 inches above top of rail or in no case higher above adjacent finihsed grade than 18 inches. Backwall of niche shall be at least 8'-6" from centerline of track and niches shall not be less than 1'-0" deep.

3. Placement Interval

Where niches are required, they shall be spaced every 25'-0" on center and when on both sides of the trackbed they shall be staggered from those on the opposite side of track by 12'-6".

CHAPTER 7
GRADE CROSSING CRITERIA

Reference Standard Plans 3100, 3106, 3108, 3120

A. General

Vehicular grade crossings pose acute problems from both a safety and maintenance perspective. As stated in Design Objectives/Guidelines, Chapter 2, no new grade crossings, either public or private, will be permitted except with approval of various agencies and then only when no other reasonable alternative is available.

By their very nature, grade crossings are a potential hazard to all who use them, both in trains, motor vehicles and pedestrians. Elimination of grade crossings whenever possible is a first order priority on any project. In addition to new grade separation structures, crossings may also be eliminated by combining multiple crossings and diverting vehicular traffic onto a nearby grade separation.

There are many elements to consider in designing or improving a crossing. These include road profile, vehicular sight distances, type, number and placement of warning devices, traffic turning movements, traffic volume, percent of truck traffic, pedestrian travel paths, railroad sight distance, railroad operating speed, track geometry and superelevation as it would affect road profile and traffic signal pre-emption if their are signalized intersections in the immediate area. These elements all affect the safety of a crossing, which is the primary concern.

Maintenance of a crossing is also a major concern. The track structure at a grade crossing experiences increased deterioration due to wet conditions, sand and salt infiltration from road surfaces, loadings from highway traffic, all exacerbated by the fact that the track structure is encapsulated by the crossing surface, making track maintenance difficult and costly. It is essential that crossings be constructed to high standards and that crossing surface material can be removed and replaced in an expedient manner.

B. Types of Crossing Surfaces/Usages

Permanent mainline track crossings shall use full depth rubber when the Average Daily Traffic Volume (ADT) for the roadway exceeds 2500 or if more than 100 trucks per day use the crossing.

Permanent crossings with lesser volumes may use the rubber rail seal and bituminous type crossing.

Temporary construction type crossings and very low volume private crossings - as determined by the Chief Engineering Officer - shall use the pressure treated timber type crossing surface.

The full depth rubber crossing shall be of a design which allows installation without bolting or lagging from the top surface into the ties and must be designed to allow installation over the standard resilient fasteners.

C. Design Criteria

1. Highway Design

a. Horizontal Geometry

The geometric design criteria for the highway approach to a grade crossing must maximize sight distance to the crossing and remove any hazards and visual distractions to the driver. Curved approaches to the crossing are undesirable. Intersections at or near the crossing are extremely undesirable. Driveways or any entrance to the roadway within 75 to 100 feet of the crossing are undesirable. Changes in pavement width or number of lanes near the crossing are undesirable. Crossing angles less than 60 degrees are undesirable.

b. Vertical Geometry

Sight distances must be maximized by removing or flattening any vertical curves which limit the stopping sight distance to values less than the predominant traffic speed on the road. Very sharp vertical curves in the vicinity of the crossing are prohibited.

c. Pavement Design

Permanent pavement shall be hot mix asphalt applied in not less than two lifts consisting of a 5 inch base course and a 3 inch top course. New pavement shall extend not less than 9'-0" from edge of crossing surface. Existing pavement shall be saw cut to produce a clean, uniform pavement edge. Pavement specifications shall conform with MBTA Standard Specification, Section 02513 - Bituminous Concrete Pavement, for Base Course and Top Course.

The pavement subgrade in the approach to crossings should be disturbed as little as possible. Where conduits, underdrains and storm drains are installed, the width of trench should be kept to a minimum and gravel backfill placed and compacted in lifts not more than 6 inches each.

2. Railroad Design

a. Geometry

Curvature through a grade crossing is undesirable. When curvature is necessary, track superelevation should be limited to 2 inches to minimize the abrupt grade changes that occur to the road surface in multiple track crossings from one track to the other. If additional superelevation is mandated, the profile of the outer track should be adjusted upward at the crossing to provide a uniform cross slope across both tracks. This type of profile adjustment is undesirable and increasing superelevation in the crossing in excess of 2 inches will not be permitted

without the approval of the Chief Engineering Officer.

Low points in the railroad profile at grade crossings should be avoided as this will exacerbate the retention of water in the subgrade at the crossing.

b. Subgrade

Maintenance of a firm, dry subgrade is essential to the satisfactory performance of a grade crossing. When a crossing is to be rebuilt, the nature and condition of the subgrade should be determined. The maintenance history of the crossing should be obtained from interviews with maintenance personnel and visual observations made to note poor track surface, fouled ballast, excess moisture and other indications of subgrade problems.

If poor subgrade problems are suspected, subsurface investigations must be undertaken to determine depth, extent and nature of the poor subgrade material. A program of subgrade modification/remediation must be prepared to allow construction of a crossing that will maintain track and roadway surface. The 5 inch hot mix asphalt underlayment, which is standard at all grade crossings, provides a good separation layer and load distribution medium. However, it should only be placed on granular material which will allow movement of moisture laterally to underdrains. The depth of excavation required below the bottom of the asphalt and replacement with granular material should be determined by the designer. In general, subgrade remediation measures beneath the asphalt layer should be initiated when the subgrade resilient modulus (Es) is less than 7500 psi or the California Bearing Ratio is less than 5.0.

The hot mix asphalt layer must be a low modulus mix with 1-3 percent air voids, (compacted), a high asphalt cement content and a high mineral-aggregate fines component. The job mix formula recommended for the hot mix asphalt is stated in Chapter 6, Section A.4.

c. Track Structure

The track structure on top of the HMA underlayment shall consist of 12 inches of crushed stone ballast (measured from bottom of tie), 7 inch x 9 inch treated timber ties 9'-0" long at 18 inch spacing through the actual crossing surface limits plus 3 ties beyond on each end and 8 foot 6 inch long ties at 19½ inch spacing to the limits of the HMA. (See Standard Plan No. 3100). In concrete tie territory, standard concrete ties may be used, however spacing and design of crossing panels must be coordinated. Rail through the crossing shall be 132 RE section continuous welded rail. Joints will not be permitted in the crossing or within 50 feet either side of the crossing surface except bonded insulated joint plug rails beyond the crossing

surface as required for crossing circuits. Transition tie section shall be placed in advance of HMA underlayment per Standard Plan No. 1108. Standard resilient fasteners and plates will be used throughout. No tie pads shall be used in the crossing when timber ties are used.

3. Conduits - Signal & Communication

a. General Requirements

Standard Plan No. 3100 indicates the minimum number and general arrangement of 4 inch Galvanized Rigid Steel (GRS) conduits required at each crossing installation. These conduits are necessary for the automatic highway crossing protection, the signal system, communication system and provision for future expansion - in most instances. At certain locations, additional conduits may be required as directed by Railroad Operations. It is essential that the ends of conduits be plugged and located by the installer by preparing an 8½" x 11" minimum sketch with swing ties to existing physical features and then a witness stake placed over the ends after backfilling. In addition, conduits which do not have cable in place shall have a pull wire installed.

Where there are fibre optics installations, the owning company(s) must be contacted during design. Measures to protect their facilities or schedule and coordinate the fiber optics company's relocation or modification must be incorporated into the contract documents.

b. Location

The general location of required conduits is defined on Standard Plan 3100. This plan is generic in nature and individual crossings may require some modifications and additions. The lateral conduits must be installed under the HMA underlayment. The side of the right-of-way to receive the 9-4 inch conduits versus the 4-4 inch conduits is a function of the location of the primary signal cables and equipment case for the crossing protection.

The location of the conduits must be coordinated to avoid interference with underdrains and storm drains or other existing and proposed utilities.

Trenching for conduits must be kept to the minimum width possible and backfill placed around the conduits must be free of rocks or other sharp, hard material.

D. Drainage Considerations

1. General

Removal of surface water and effective reduction of pore water pressure in the subgrade are important measures for providing a crossing which will maintain smooth rail and highway surface with minimal maintenance. Measures which will accomplish these are well known, commonly used in general site work and include perforated pipe underdrains in combination with french drains (ballast filled trenches).

2. Avoid Low Points At Crossings

Highway profiles which have a low point in the crossing are very undesirable. To the extent possible, highway profiles and grading should be set to form a low point or swale off the crossing area parallel to the track on either side of the crossing. This will intercept the surface runoff from the road before reaching the crossing. This water can be directed into a closed drainage system, where available, or directed into adjacent Right-Of-Way (ROW) ditches if they are available.

3. Underdrains

Perforated pipe underdrains set in ballast filled trenches on either side of the HMA underlayment (see Standard Plan 3106) and protected from clogging with filter fabric are an effective means of removing water from the crossing area and lowering pore water pressure. However, they are fully effective only when the underdrains can outlet to some lower point. ROW ditches are the primary choice for this purpose, if present, and if water levels are normally not so high as to prevent flow from the underdrains.

Existing storm water drainage systems, if present, can provide a positive discharge point. Permission from the local department of public works is necessary and the capacity and hydraulics of the system should be investigated to determine if it surcharges on a regular basis.

Piping to a nearby natural low point away from the right-of-way is another option. If wetlands or watercourses are the ultimate discharge point, an order of conditions and other requirements may be imposed by the local conservation commission.

Piping to a drywell, removed from the immediate area of the crossing, is a possible solution when no other option is available. This would typically not be effective during periods of high rainfall but provide for removal of water from the crossing at other times.

4. Storm Drains

Separate storm drains must be used to carry surface water runoff through the crossing area where right-of-way ditches are present. Use of perforated pipe underdrains for this purpose is prohibited.

Where there are existing municipal storm drains passing through the crossing, their condition and type of material should be determined prior to crossing reconstruction. If they are in poor condition, consideration may be given to replacement during crossing reconstruction.

E. Existing Utilities

The designer should determine the presence and condition of all utilities in the crossing area and coordinate protection and possible replacement with the responsible utility or municipality during crossing reconstruction.

F. Plan Preparation/Design Requirements

1. General Requirements

When grade crossings are to be reconstructed, the designer shall provide an overall site plan detailing existing and proposed physical features and location of all existing and proposed signal equipment and cases. The plan should include, or be supplemented by an additional plan, delineating existing utilities above and below ground and show the proposed location of new ducts, cables, drainage and pole lines. Road profiles must be provided, and if trackwork is being done, profiles of the railroad and amount of superelevation at the crossing. Limits of pavement renewal shall be defined on the plans and road profiles.

2. Design

In addition to elements noted in this chapter, the designer must determine placement of equipment cases, crossing gates and all other proposed construction, considering sight distance, clearances, maintenance access and interference with existing facilities. Placement of new equipment must be fully defined on the plans. If crib walls, embankment or cut widening, or ditch relocation is required for placement or support of new equipment, these elements must be delineated and detailed on the plans.

Section II

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

RAILROAD OPERATIONS

COMMUTER RAIL DESIGN STANDARDS MANUAL

VOLUME I
SECTION II

STATIONS AND PARKING

Revision No. 1
April 19, 1996

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CHAPTER 1
CIRCULATION AND PARKING

I. INTRODUCTION

Design standards for vehicular and pedestrian circulation and parking facilities at commuter rail stations are addressed in this section. The guidelines contained herein are intended to direct design consultants in the development of plans and details that will conform to the Authority's current goals for commuter rail station design. These guidelines include design criteria for roadways, walkways, stairs, ramps, and parking lots. Current State and Federal rules, regulations and standards for accessibility are applicable to commuter rail station facilities. (Refer also to the MBTA Guide to Access).

It should be emphasized that these standards are not exhaustive and will leave many site specific issues unaddressed. It is the design consultant's responsibility to seek direction from the Authority where situations arise not covered by these guidelines. Further, it is the responsibility of the design consultant to review the latest applicable Federal, State, and local regulations. Where conflict may exist between such regulations, these guidelines, and/or the MBTA Guide to Access, the most stringent shall apply.

II. DESIGN OBJECTIVES

Safety, efficiency, and accessibility are the principal objectives to consider in the design of circulation and parking facilities at commuter stations. The organization and detail of the station design must also address specific issues of security, maintenance, and snow removal.

III. DESIGN GUIDELINES

A. Separation of Circulation Modes

For the maximization of safety station site circulation modes of pedestrian, vehicular, and rail movements should be separately delineated. Locations where circulation modes cross or interface must be well identified and sight lines maximized.

B. Arrival/Departure Modes

Station design must address the variety of arrival/departure modes:

- Pedestrian walk-in and bicycles
- Public transportation, including taxis
- Drop-off/pick-up
- Park and ride

Pedestrian, public transportation, and drop-off/pick-up modes should be encouraged by minimizing walking distances from site entry points, and curbside stops to the platform.

C. Pedestrian Circulation

1. General Principles

a. Pedestrian pathways should be direct, well defined, and provide a clear indication of where they lead.

b. Pedestrian access from the surrounding community should be encouraged by providing a direct, paved walkway to the platforms.

c. An accessible route of travel, free from steps, must link the accessible station entrance with public sidewalks, bus stops, parking and passenger loading zones. The platform may be considered to be a part of this accessible entrance route. With exceptions allowing for specific site conditions, this accessible route of travel should be the primary route for all station users.

2. Walkways

Note:
The following section represents a partial summary of the design constraints for walkways. Consult the MBTA Guide to Access and relevant codes for additional information.

a. Width: 5'-0" preferred minimum
4'-0" absolute minimum

Notes:
1. For widths less than 5'-0", provide 5'-0" by 5'-0" passing spaces at intervals not to exceed 200'-0".
2. Subject to Authority approval and code compliance, the clear width of an accessible route may be a minimum of 36" excluding curb stones and 32" at columns or other obstructions having a depth less than 24".

b. Slope in the direction of travel: 5% (approx. 5/8" per foot) absolute maximum

Note:
If the slope is greater than 5%, it must be treated as a ramp with a maximum slope of 8%.

Cross-slope: 2% maximum

c. No level change greater than 1/2" is permitted unless a ramp is provided. Level changes between 1/4" and 1/2" must be beveled with a maximum slope of 1:2.

d. Walkway surfaces must be slip-resistant (minimum static coefficient of friction of 0.6) with all joints finished flush.

e. Walkways adjacent to roadways should be physically separated by curbing, guardrail, or bollards for safety and to prevent encroachment by vehicles.

Note:
The use of bollards should be minimized as they may interfere with snow removal.

f. Where sidewalks are located immediately adjacent to parking areas, vehicle overhang from 90° or angle parking should be accounted for in the layout of walkways to ensure that required sidewalk width is maintained.

g. Snow removal and storage must be considered in the location and design of sidewalks.

h. Sidewalk shall not be utilized simply as a design element, such as an edge treatment along a roadway. Minimize the amount of sidewalk to that which is truly required.

3. Crosswalks

a. Locate crosswalks to maximize visibility between pedestrians and vehicles.

b. Width: Equal to or wider than walkway width. (6'-0" minimum)
Curb cuts at marked crossings must be wholly within the crossing markings (excluding flared sides).

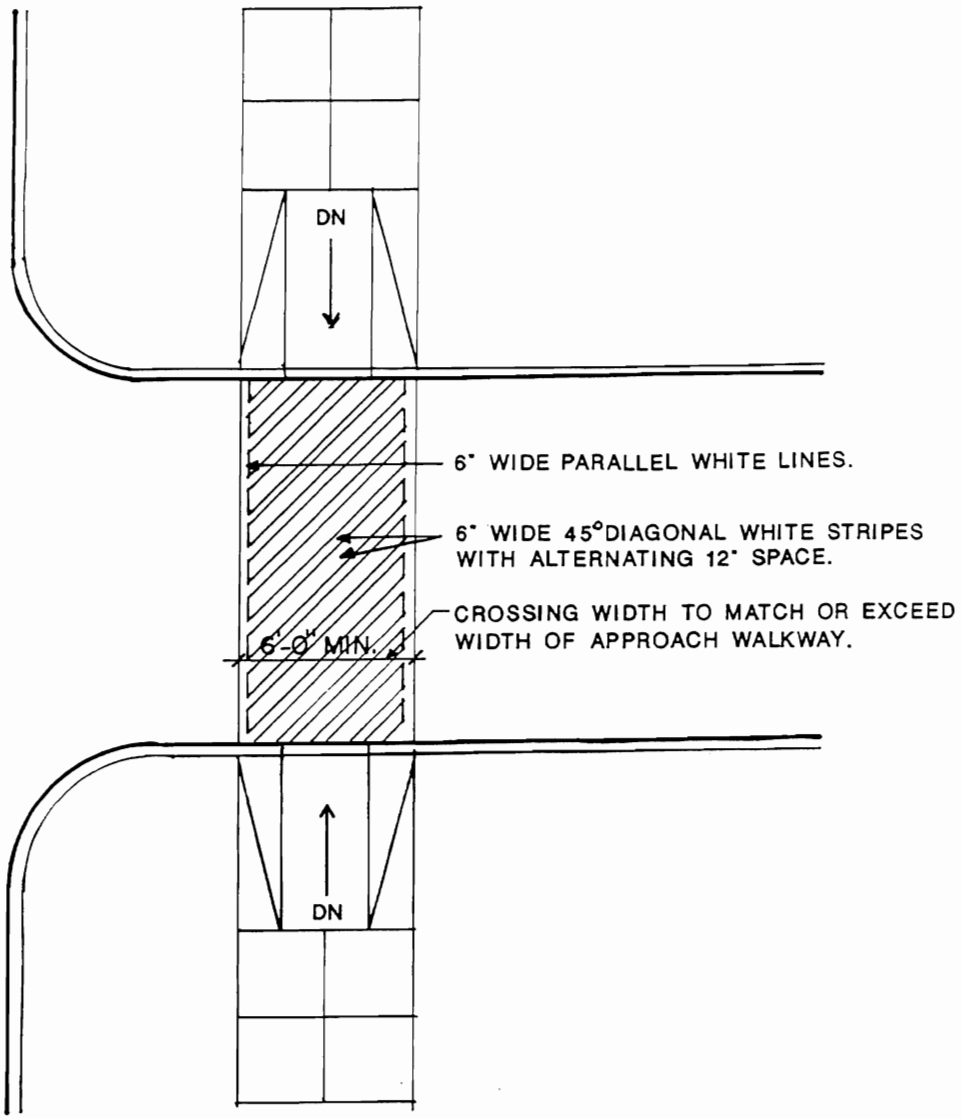
c. Pedestrian roadway crossings should be defined by white warning stripes painted on the surface of the roadway (See diagram following).

d. Curb cuts must be provided wherever an accessible route crosses a curb. The preferred minimum width of curb cuts shall be 40" (absolute minimum no less than 36"), not including sloped sides. The maximum slope of the curb ramp shall be 1:12.

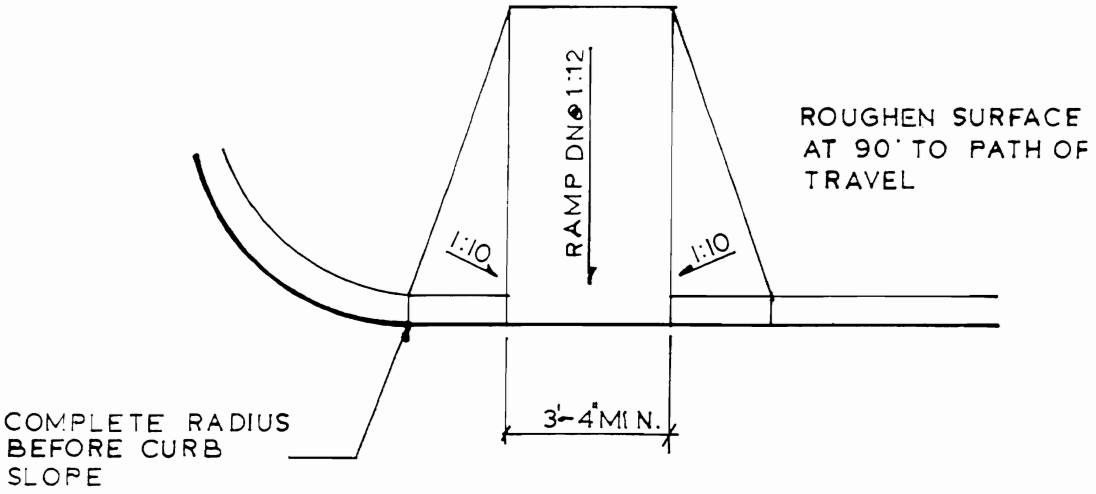
e. Curb cut ramps must be installed perpendicular to the curbs. Diagonal curb cuts are not allowed.

Note:
Consult the MBTA Guide to Access for additional information on the location and design of curb cuts.

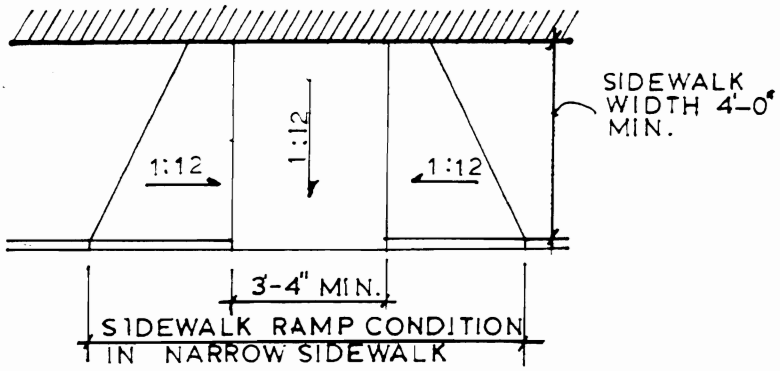
Typical Marking of Pedestrian Roadway Crossing



Typical Curb Cut



Curb Cut in Narrow Sidewalk



4. Ramps

Note:
The following section represents a partial summary of the design requirements for ramps. Consult the MBTA Guide to Access and applicable Federal and State codes for additional information.

a. Width: 4'-0" absolute minimum
(measured from inside to inside of railing)

b. Slope: 8% maximum
(1" rise in 12.5" run)

Note:
Ramps shall have a cross slope that is 1:50 (2%) or less.

c. Distance between landings: 30'-0" maximum

d. Length of Landings: Equal to width of ramp
(5'-0" minimum length)

Note:
Where a ramp changes direction the landing should be at least 5'-0" by 5'-0". Adequate drainage must be provided to prevent ponding of water at landings.

e. Provide a level area that is 5'-0" in length and equal to the width of the ramp (2% maximum slope in either direction) at the top and bottom of each ramp.

f. Ramps shall have a slip-resistant (minimum static coefficient of friction of 0.8) and a glare-free surface.

g. Run-off is the clear area between the end of a stair or ramp and the nearest obstruction conflicting with pedestrian movement.

(1) The run-off to an obstruction such as a wall, kiosk, or pier should be equal to 1.7 times the width of the ramp.

(2) The run-off to the edge of a queuing space, such as the front edge of a platform, should be at least 10'-0".

h. Ramps and landings with drop-offs shall have curbs, walls, railings or projecting surfaces that prevent people and wheel chairs from slipping off the ramp. Curbs shall be a minimum of 2" high. Protective railings shall allow a maximum 2" vertical gap above the ramp surface. Projecting surfaces must extend a minimum of 12" beyond the outside of the guard/hand rail.

i. Handrails at ramps:

(1) Provide continuous handrails on both sides of all ramps.

(2) Heights: 2'-10" and 1'-7"
(measured vertically from the ramp surface)

(3) Extension: 1'-0" minimum

Note:
Handrail should extend beyond top and bottom of ramp, return to a wall or post and must be parallel to ground surface.

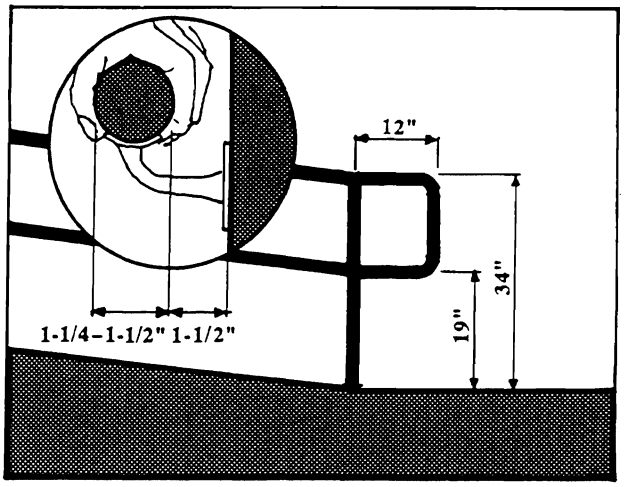
(4) Handgrip: Not less than 1 1/4"
Not more than 1 1/2"
(outside diameter)

Note:
Handgrip should be round or oval in cross-section, should have a smooth surface with no sharp corners, and should be uninterrupted for its entire length to provide a continuous gripping surface.

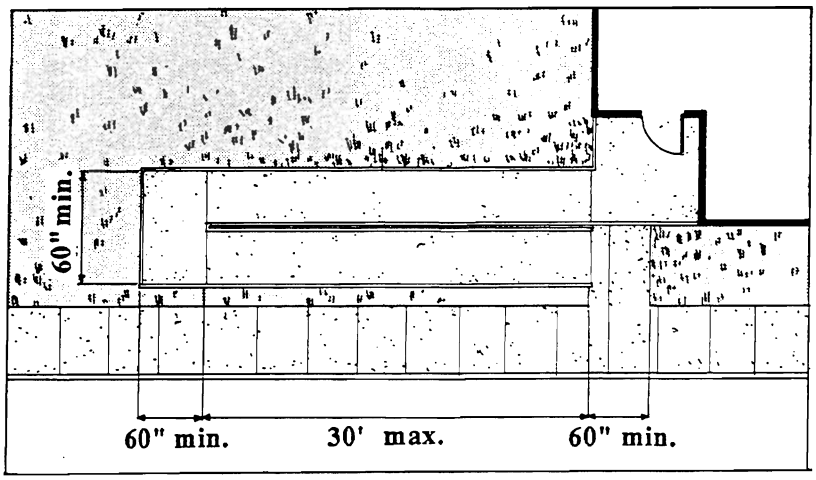
(5) Handgrip Clearance: 1 1/2"
(measured between wall and the wall-side face of the handgrip)

k. Where there is a vertical drop at the side of a ramp, provide pedestrian guardrail. (Refer to paragraph 6. Pedestrian Guardrails.)

Ramp Landings



Ramp Handrails with Extensions



5. Stairs

Note:
The following section represents a partial summary of the design constraints for stairs. Consult the MBTA Guide to Access and relevant codes for additional information.)

a. Width: 6'-0" preferred minimum
4'-0" absolute minimum

b. Landings: Every 12'-0" of vertical rise

Length: Equal to width of stair
(4'-6" absolute minimum)

c. Riser Size: 6"< R <7"
("<" = less than)

Tread Size: 11"< T <13"

Note:
These standards represent extremes; riser-tread ratios should be calculated using the following formula:

$$2R + T = 25"$$

The treads and risers of any stair must be of a uniform dimension. The minimum number of risers for any stair is three, and the risers themselves should be closed. Stair treads shall not have an abrupt projection of nosing.

d. Slope of riser: 1 1/4" maximum
(measured from the horizontal projection of the tread below)
Riser to tread angle: Greater than 70 degrees
(See diagram)

e. Stair treads should pitch to avoid ponding of water (a maximum of 1/8" per foot).

f. Stair treads shall have a slip-resistant (minimum static coefficient of friction of 0.6), glare-free surface.

g. Handrails at stairs:

(1) Provide continuous (not interrupted by newel posts or other obstructions) handrails on both sides of all stairs. When stairs are greater than 7'-4" in width, intermediate rails are required.
(2) Heights: 2'-10" and 1'-7"
(measured vertically from nosing)

(3) Extension: 1'-0" minimum (top)
1'-0" minimum + length of one tread (bottom)

Note:
At the top, the extension shall be parallel to the walking surface; at the bottom, the handrail shall continue to slope for the distance of the width of one tread, then shall be parallel to the walking surface. Both handrail extensions should return to a wall or post.

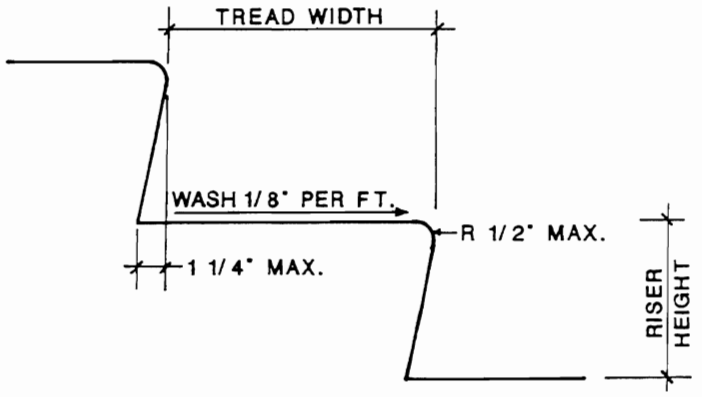
Handrail extensions are not require if they would impede travel or create a hazard on the landing.

(4) Handgrip: Not less than 1 1/4"
Not more than 1 1/2"
(outside diameter)

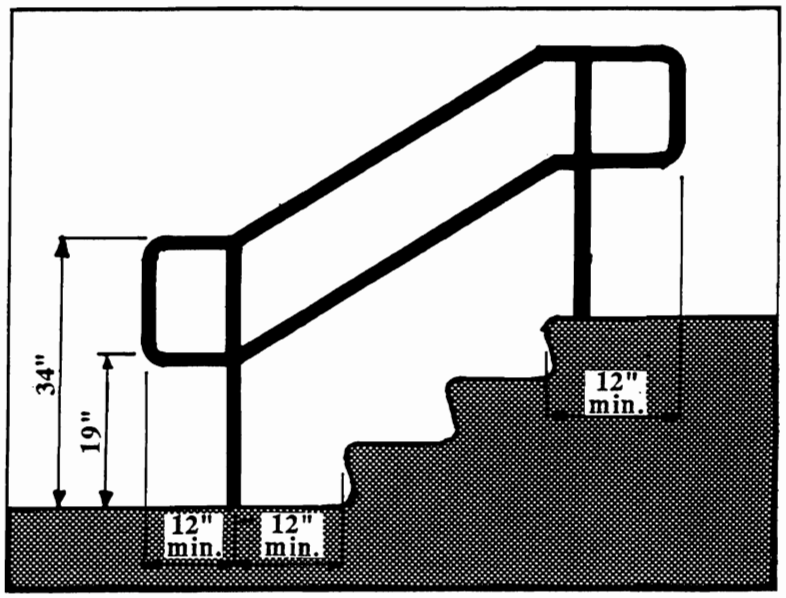
Note:
Handgrip should be round or oval in cross-section, should have a smooth surface with no sharp corners, and should be uninterrupted for its entire length to provide a continuous gripping surface.

(5) Handgrip Clearance: 1 1/2"
(measured between wall and the wall-side face of the handgrip)

Stair Nosing



Stair Handrail with Extensions



6. Pedestrian Guardrails:

Note:
The following section represents a partial summary of the design constraints for guardrails. Consult the MBTA Guide to Access and relevant codes for additional information.

a. A pedestrian guardrail is a system of building components located on the open side of walking surfaces for the purpose of minimizing the possibility of an accidental fall from the walking surface to a lower level.

b. Use pedestrian guardrails where required by applicable code and in the following situations:

(1) Where there is a direct vertical drop in excess of 4'-0" closer than 2'-0" to a walkway, parking area, or roadway.

(2) Along all open-sided walkways, mezzanines, and landings.

(3) Where there is a vertical drop at the side of a ramp or stair.

c. Height: 3'-6" minimum
(measured vertically the leading edge of the tread or from the top of the walking surface)

d. Openings: 6" maximum opening

e. Loading Requirements:

All required pedestrian guardrails shall be designed and constructed to meet the structural loading conditions set forth in the most recent edition of the Massachusetts State Building Code.

f. Do not use unnecessary horizontal elements that may provide an easy surface for climbing.

7. Track Crossings

a The location and number of grade level pedestrian track crossings shall be determined on a site specific basis by the Authority.

Note:
Grade level crossings are not permitted at stations on high speed lines (speeds greater than 80 miles per hour).

b. Grade level crossings:

(1) Pedestrian crossings should be located where pedestrian traffic is greatest. Grade level crossings should be offset from areas on the platform where the train doors are likely to align when trains are stopped for loading or disembarking passengers. Crossings should be located to be blocked when a train is stopped within the station to prevent pedestrian track crossings.

(2) Grade level track crossings should be offset from access points to the platform. Design layout should seek to reduce the probability of pedestrians stepping out into the crossing without looking for on-coming trains.

(3) Width: 8'-0" minimum

(4) Slope in the direction of travel: 5% (approx. 5/8" per foot) absolute maximum

Cross Slope: 2% (approx. 1/4" per foot) absolute maximum

Note:
The above slopes apply to walking surfaces within the crossing. The platform should slope down at a maximum slope of one in twelve (1:12) to the level of the crossing to permit access for wheelchairs and maintenance vehicles.

No level change greater than 1/2" is permitted unless a ramp is provided. Level changes between 1/4" and 1/2" must be beveled with a maximum slope of 1:2.

(6) The crossing surface should be slip-resistant (maximum static coefficient of friction should be 0.6 for walking surface and 0.8 for ramped surfaces). Material should be impervious to oil and grease.

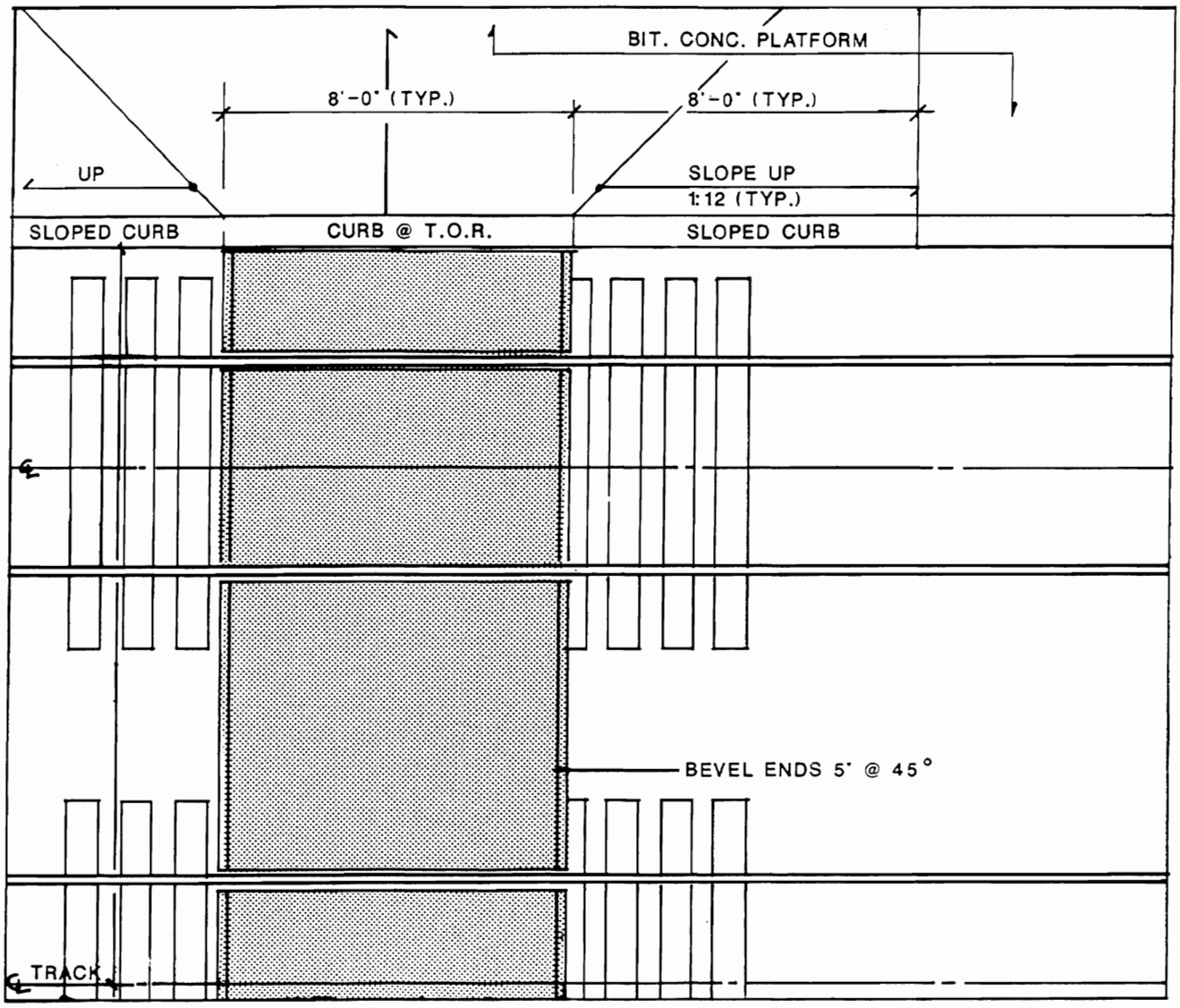
(7) The construction of pedestrian crossing construction should be 'panelized' for ease of removal for track maintenance.

(8) The gap between rail and adjacent track crossing surfaces shall be governed by American Rail Engineer's Association standards and shall comply with State and Federal accessibility rules, regulations and standards. The maximum permissible gap at the inner edge of each rail is 2-1/2".

(9) Detectable warning surfaces for persons with visual disabilities shall be provided at the edge of all track crossings.

(10) Provide fully automated crossing warning systems at each pedestrian crossing on main line tracks. Secondary and other low speed tracks may be exempted from this requirement on a site specific basis. Locate warning signs on all crossings to be visible from each entry to the crossing. These signs should have the phrase "Look Before Crossing" on both sides. (See Chapter on "Graphics" for design criteria for the standard sign.)

Pedestrian Track Crossing



c. Grade separated crossings:

(1) All new pedestrian crossings on the Providence line shall be grade separated.

(2) Locate new grade separated crossings where pedestrian traffic is greatest--e.g. at the midpoint of platforms or at the point of access to/from parking. Reuse existing grade separated crossings where possible.

(3) Width: 6'-0" minimum (open, elevated crossings)
12'-0" minimum (enclosed passageways, tunnels)

(4) Slope in the direction of travel: 5% (approx. 5/8" per foot) absolute maximum

Cross Slope: 2% (approx. 1/4" per foot) absolute maximum

(5) Grade separated structures must comply with rules and regulations governing accessibility. Access shall be provided by ramp or elevator.

(6) All grade separated crossings shall be illuminated in accordance with the guidelines presented in Chapter "Lighting".

(7) Elevated grade separated structures shall be enclosed with metal grating or fencing with a maximum openings of 1" between members as a means of preventing dropping or throwing debris at trains. Limit such protective enclosures to directly over the track area to facilitate snow removal.

(8) Pedestrian bridges and associated ramps must be covered to protect against rain and the accumulation of snow on the walkway surfaces.

D. Vehicular Circulation

1. General Principles

a. Provide the most direct roadway access possible between the entrance to the site and the drop-off/pick-up area.

b. Where site conditions permit, vehicle access to the site should favor the inbound side.

c. Provide convenient loop turn-arounds for drop-off/pick-up vehicles (buses, taxis, private automobiles).

d. Roadways in public rights-of-way that are to be relocated or improved shall be designed to current standards set forth by the Massachusetts Department of Public Works and as required by local codes.

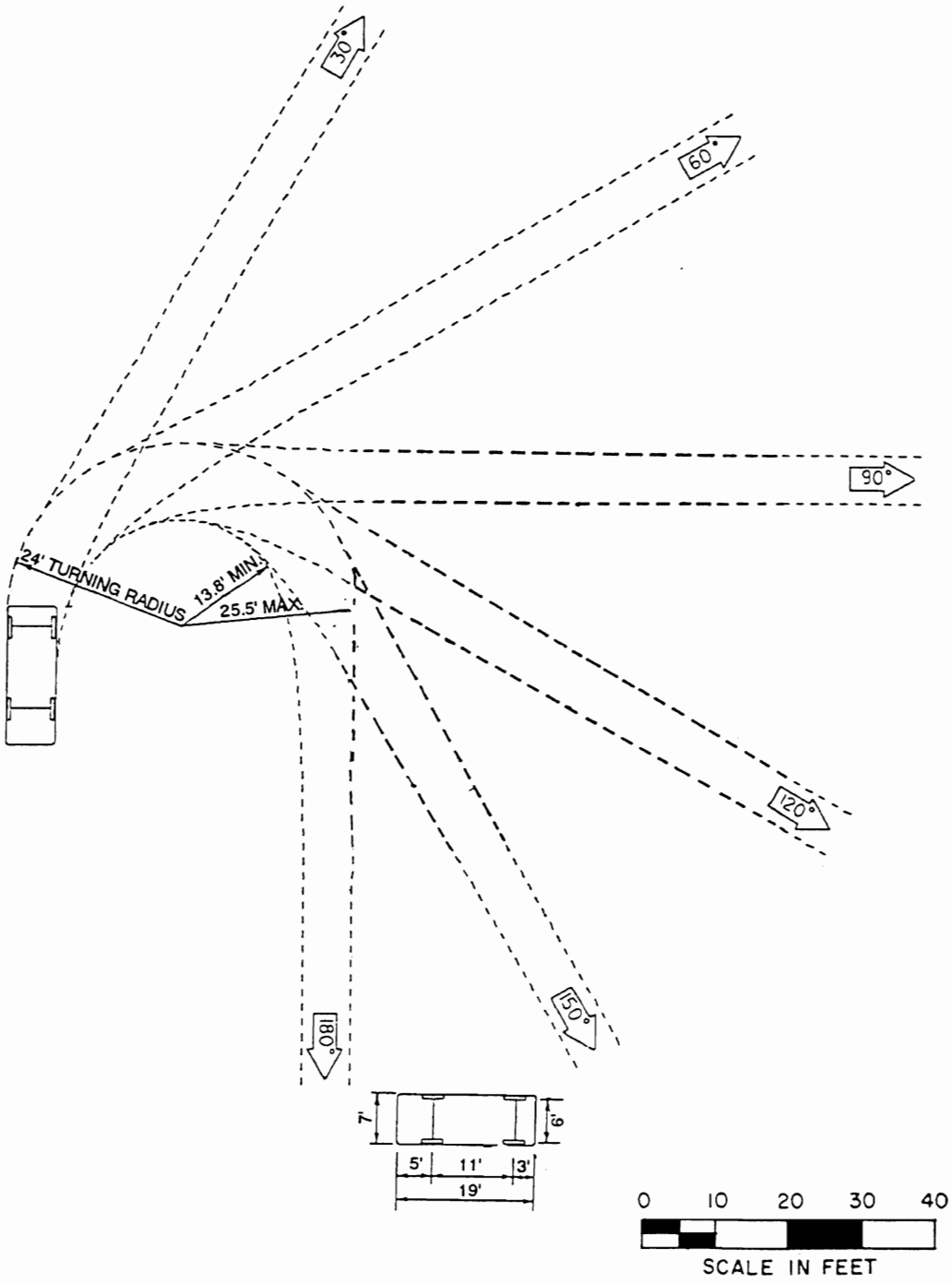
2. Vehicle Turning Radii

Note:
The following table is taken from the 1990 edition of A Policy on the Geometric Design of Highways and Streets.

Design Vehicle	Minimum Turning Radius	Minimum Inside Radius	Minimum Turning Path
Passenger Car (P)	24	13.8	25.5
Single Unit Transit Bus (BUS)	42	24.4	46.5
Single Unit Truck (SU)	42	27.8	44.1
Semitrailer (WB 50)	45	19.2	46.3

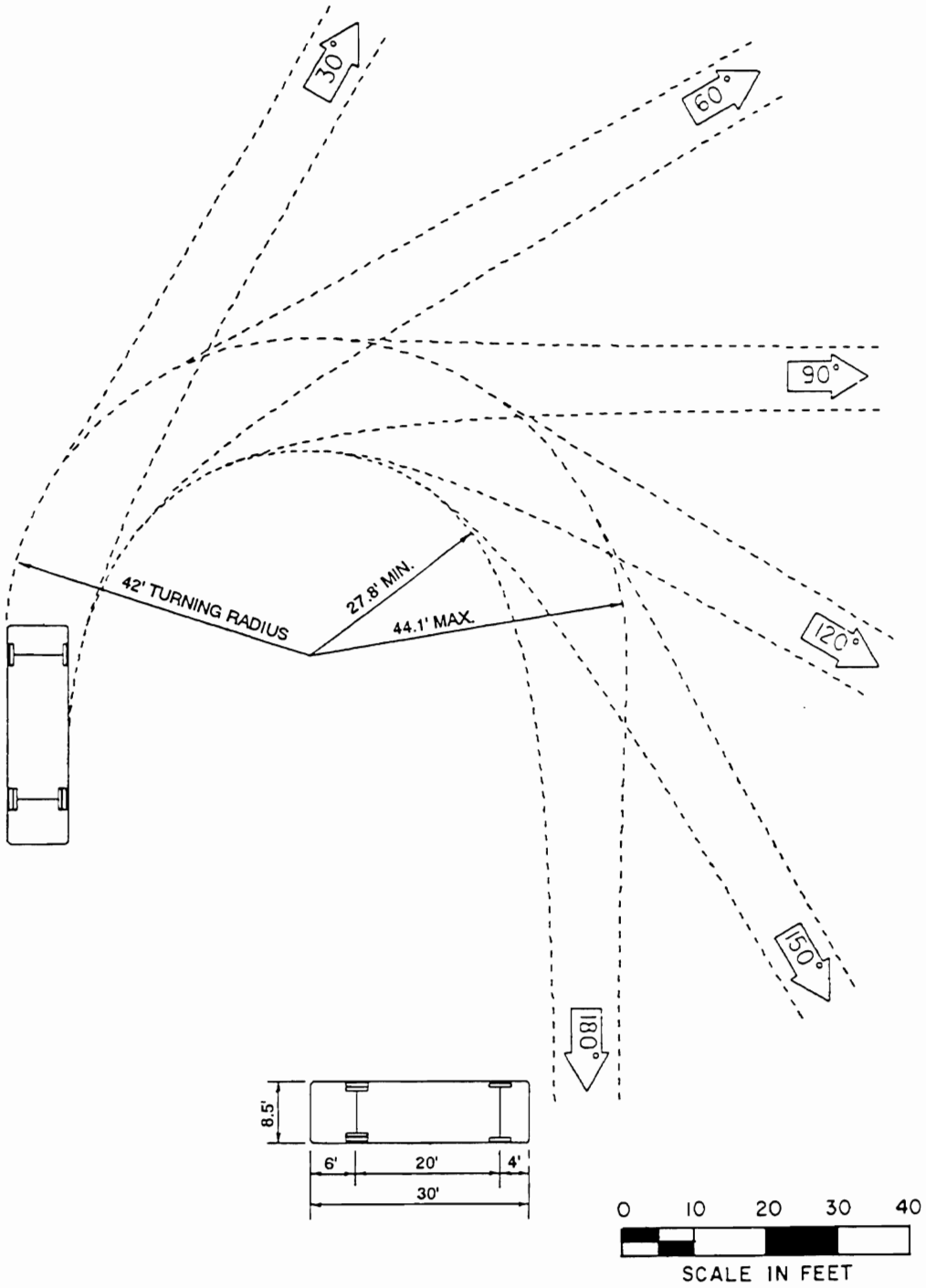
Minimum Turning Paths of Typical Vehicles

The following diagrams are take from
A Policy on the Geometric Design of Highways and Streets, 1990 ed.



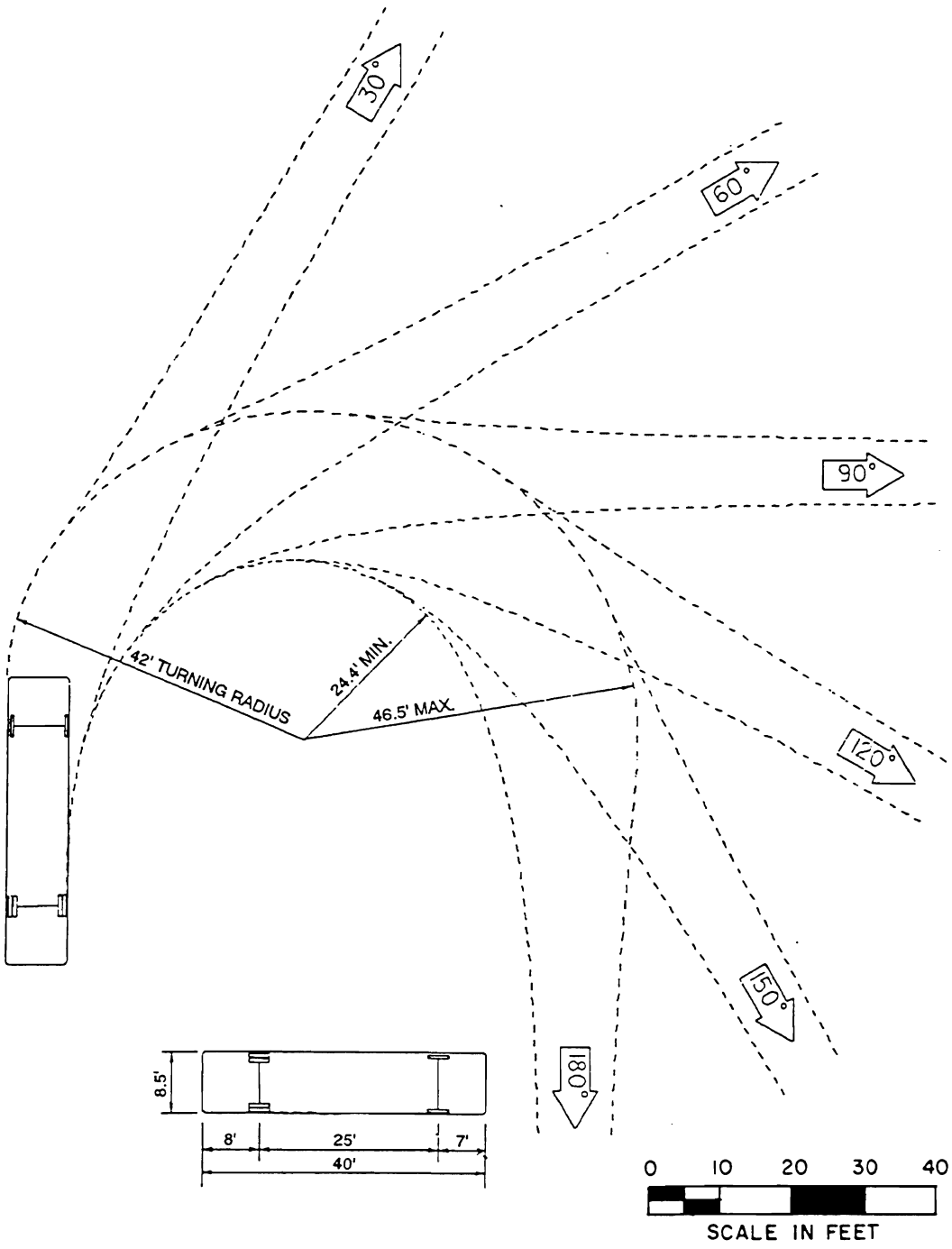
Minimum turning path for P design vehicle.

Minimum Turning Paths of Typical Vehicles



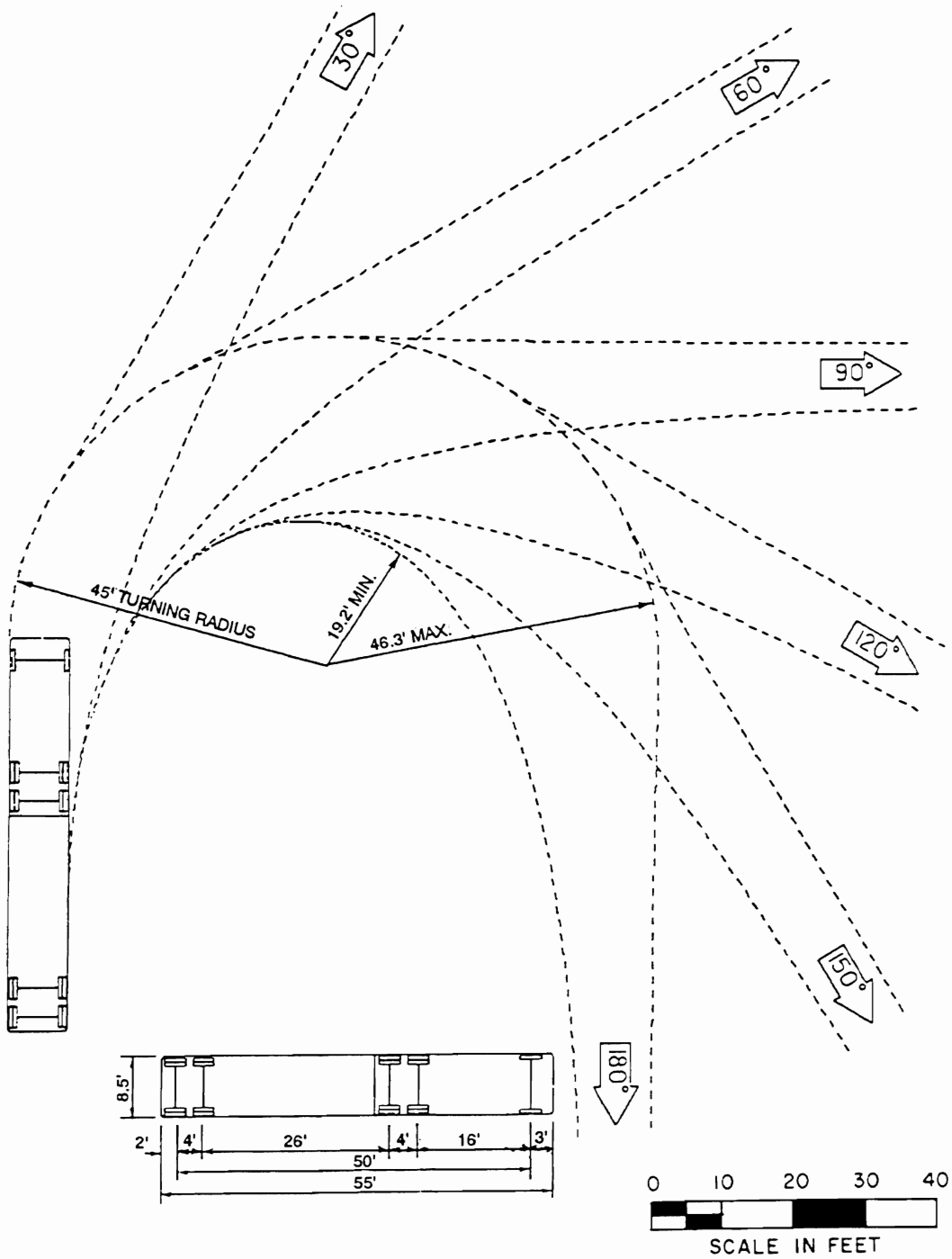
Minimum turning path for SU design vehicle.

Minimum Turning Paths of Typical Vehicles



Minimum turning path for BUS design vehicle.

Minimum Turning Paths of Typical Vehicles



Minimum turning path for WB-50 design vehicle.

3. Standard Roadway Dimensions and Gradients

a. The preferred minimum roadway lane width is 12'-0". The absolute minimum lane width is 10'-0". The absolute minimum lane width for a one-way single lane is 16'-0".

b. Roadways shall be cross pitched to provide positive drainage. The preferred cross pitch is 2% (approx. 1/4" per foot). The absolute minimum cross pitch is 1% (approximately 1/8" per foot). The maximum cross pitch is 3% (approx. 3/8" per foot). Where possible, roadways should be crowned in the middle and drain to the edges.

c. Roadway gradients:

Vehicle	Roadway Gradients (Slope)
Automobile	10% maximum (approx. 1 3/16" per foot) for ramps, access roadways, and driveways; 6% maximum (approx. 3/4" per foot) sustained grade for safe operation; 5% maximum (approx. 5/8" per foot) on roadways subject frequent ice, snow, sleet, and fog.
Bus	10% maximum (approx. 1 3/16" per foot) operating grade; 6.5% maximum (approx. 13/16" per foot) design grade--controlled by safety considerations and desirable operating conditions in the winter months.

d. Where an accessible route crosses a roadway, the maximum allowable slope in the direction of travel is 5% with a maximum cross slope of 2%.

4. Vehicle Entrances and Exits

a. The number and location of vehicle entrances and exits at a station is determined by many factors, including parking lot size, drop-off/pick-up volume, site topography, traffic volumes on adjacent streets, and adjacent land uses.

b. The recommended distance between site entrances/exits and adjacent street intersections along various types of roadways is presented below:

Type of Roadway	Minimum Distance (ft)	Preferred Distance(ft)
Major Arterial	200	400
Minor Arterial	150	300
Collector/Local Street	100	200

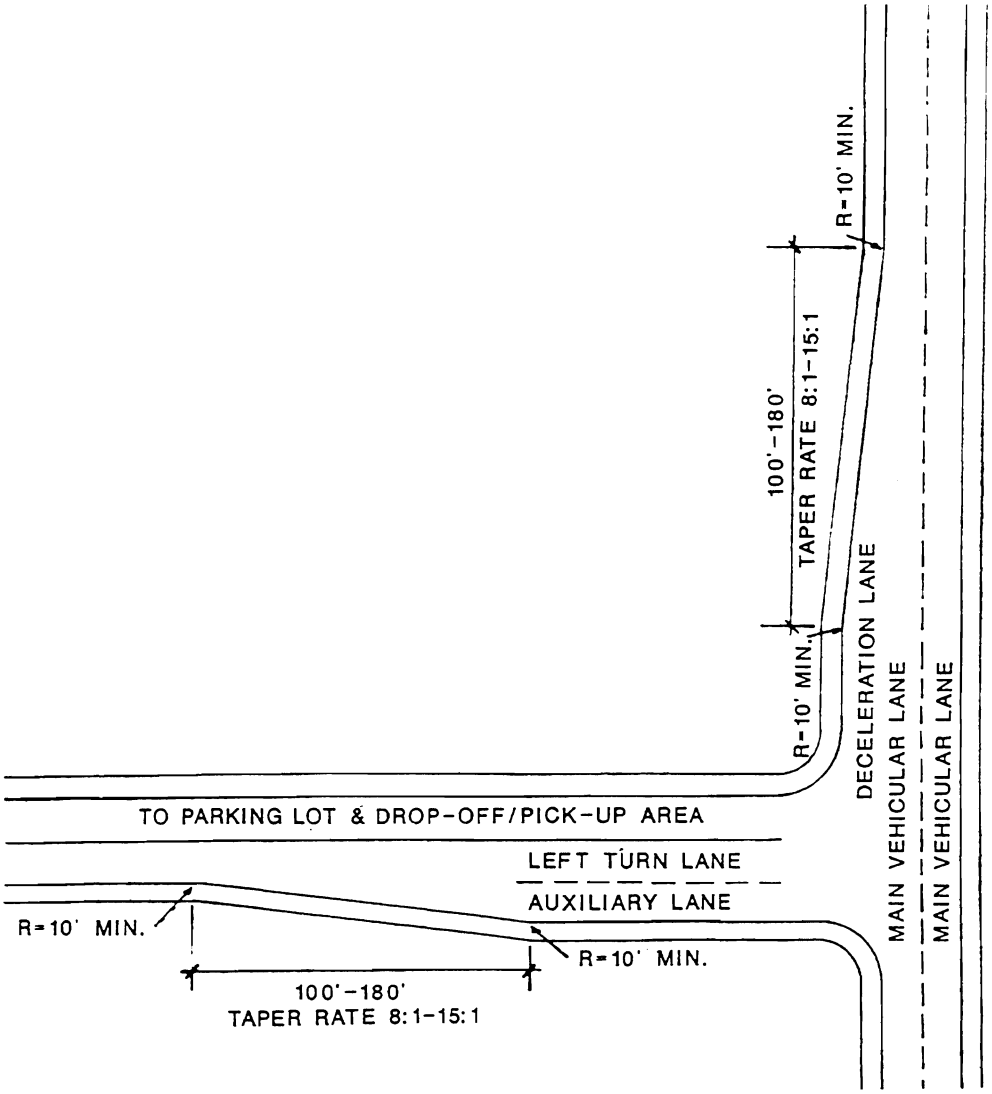
c. Entrance and Exit Design

(1) At exits where a moderate number of left hand turns is anticipated, a second auxiliary exit lane should be considered to separate left and right hand turns. The preferred width of auxiliary lanes is 12'-0"; the minimum width is 10'-0". (See Diagram following.)

(2) Vehicle storage length is the area required to accommodate vehicles exiting the site. This area should be separate from and not interfere with the operation of vehicles in the remainder of the parking lot.

d. For further information on the design of intersections, auxiliary lanes and deceleration lanes, see A Policy on the Geometric Design of Highways and Streets, published by the American Association of State Highway and Transportation Officials.

Layout of Auxiliary and Deceleration Lanes



5. Drop-off/Pick-up Areas (Passenger Loading Zones)

   a. Provide drop-off/pick-up areas at all stations, even those sites where no long term parking is provided. Locate the drop-off/pick-up area within a maximum 100 feet of the station platform and ensure compliance with the Rules and Regulations of the Architectural Access Board (AAB) of the Commonwealth of Massachusetts. Accessible drop-off/pick-up areas shall be identified with international symbol of accessibility signs.

Note: As of the date of this writing, the requirement of the Americans with Disabilities Act Accessibility Guidelines (ADAAG) for tactile warning material at curb-side locations has been suspended.

b. Limit the size of drop-off/pick-up areas. Without strict enforcement of parking restrictions, all-day parkers will utilize drop-off/pick-up areas. Parking lot aisles can be used for queuing of vehicles waiting to pick up passengers.

c. Drop-off/Pick-up Area Layout:

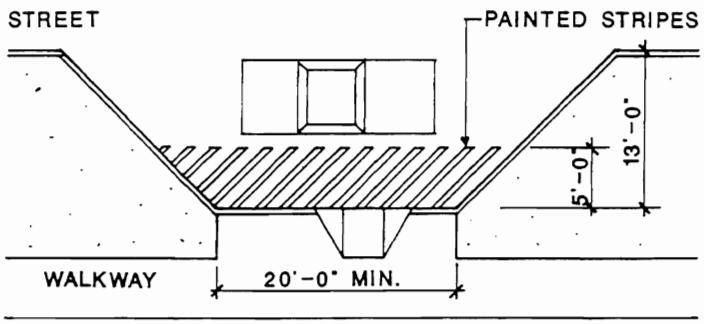
(1) The drop-off area must be designed for accessibility, providing a 5'-0" wide aisle space between the vehicle and the curb over its full length. Provide curb cuts within the drop-off area.

Drop-off areas should be designed for right-hand curbside drop. (See Diagram)

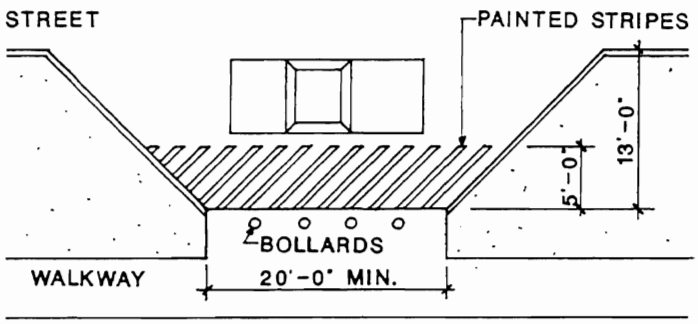
(2) Where passengers transfer from local bus lines to commuter rail, a bus drop-off/pick-up area with a berth size of 80'-0" by 11'-0" should be provided.

At bus stops where a lift will be deployed:
- Provide firm, stable surface a minimum clear length of 96" measured from the curb or vehicle roadway.
- Provide minimum 60" clear width, measured parallel to vehicle and roadway.

Passenger Loading Zone



Passenger Loading Zone Without Curb



Passenger Loading Zone With Curb

E. Parking Lot Layout

1. General Principles

Factors such as site topography, location of access roads, land availability, adjacent land use, and community requirements will determine in large part the layout of parking facilities. However, other factors to consider in the initial planning for parking lots are:

a. Where possible, parking layout should be designed to maximize use of the accessible route to the platform. At low platforms, this is typically toward the outbound end, where the access platform is located.

b. Avoid dead end aisles unless a turnaround is provided.

Where turnarounds are not possible in dead-end aisles, provide one striped space and sign it as a "turning-space-only" to eliminate the need to back out the length of the parking lot.

Provide for snow removal at the end of dead end aisles.

2. Parking Layout

a. Bay Orientation

Site conditions permitting, parking bays should be laid out perpendicular to the track and platform to allow people to walk down the aisles to the platform.

(As a rule of thumb, if a site has a curb to curb dimension measured at right angles to the track which is greater than 200 feet, the parking bays should be perpendicular to the track and platform. However, there may be specific site conditions or circulation requirements which dictate an orientation parallel to the track and platform.)

b. Parking Stall Orientation

90 degree parking is preferred. Use diagonal parking only when 90 degree parking is not feasible. Diagonal parking should not be used in structures. Follow accepted standards for diagonal parking such as the Handbook of Landscape Architectural Construction, published by the Landscape Architecture Foundation.

c. Perimeter Parking

Use 90 degree parking around the entire perimeter of the site where possible to maximize the capacity of the lot.

3. Dimensional Guidelines

a. General Notes:

Deviations from the dimensional guidelines shown in the accompanying diagram may be permitted in site-specific situations, however it is the responsibility of the design consultant to bring such deviations to the attention of the Authority for review and approval.

90 degree parking spaces may be shortened by up to 2'-0" where vehicles can overhang the curb. Vehicle overhangs must not interfere with the required clear width of an accessible pathway.

Avoid single row parking in parking structures.

b. Standards for 90 degree Parking for Use by the Physically Disabled

Provide minimum 8'-0" wide spaces with an adjacent 5'-0" wide striped access way. Depth, aisle, and bay dimensions should comply with those requirements for parking lots and structures of the Rules and Regulations of the AAB and the ADAAG.

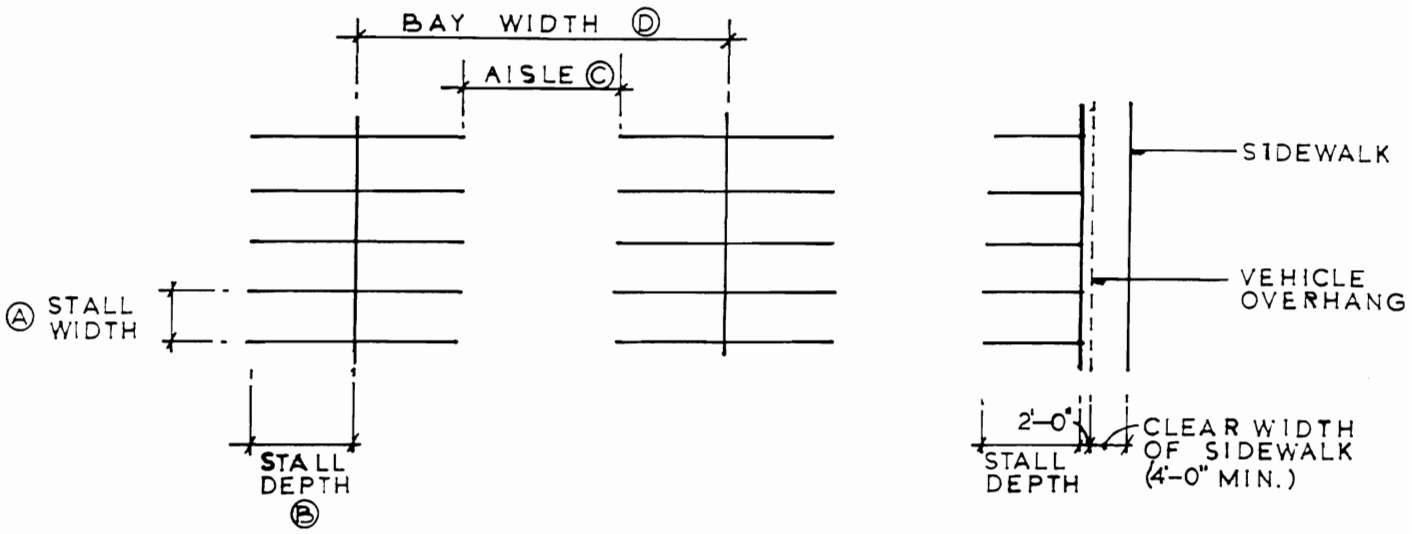
Two spaces may share the same 5'-0" access way. Provide sidewalk ramps as necessary at the end of access ways to connect with the accessible route to the platform. Where accessible spaces are grouped together, it may be advantageous to lower the sidewalk to the level of the parking spaces. Accessible parking spaces and access aisles shall have surface slopes not exceeding 1:50 (2%) in all directions.

c. Standards for Parallel Parking on Surface Lots

Use parallel parking only where other layouts are impractical. Do not use parallel parking in any location where it might interfere with heavily traveled vehicular access routes.

Parallel parking spaces should be 8'0" wide by 22'0" long.

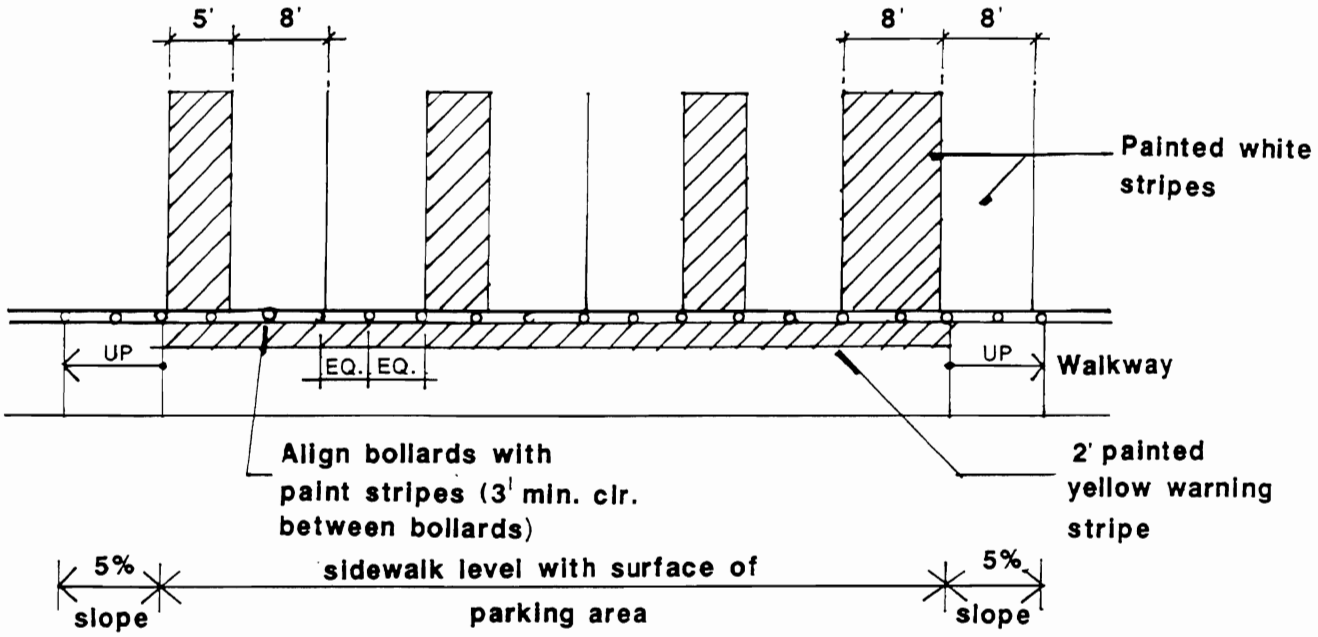
Standard Parking Stall Layout



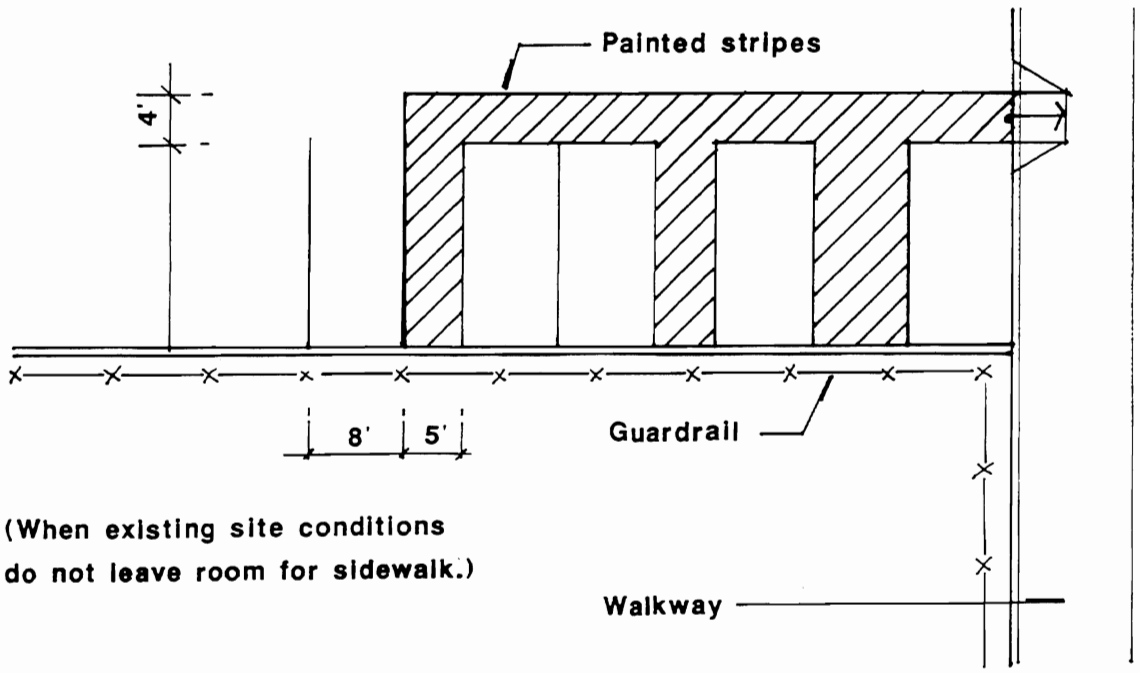
90° PARKING IN SURFACE LOTS	TWO ROWS OF CARS STANDARD PREF.	STANDARD ALT. BAY < 60 FT.	COMP.		ONE ROW OF CARS STANDARD PREF.	STANDARD ALT. BAY < 43 FT.	COMP.
Ⓐ STALL WIDTH	8'-3"	8'-6"	8'-0"		8'-3"	8'-6"	8'-0"
Ⓑ STALL DEPTH	17'-0"	17'-0"	15'-0"		17'-0"	17'-0"	15'-0"
Ⓒ AISLE	26'-0"	24'-0"	24'-0"		26'-0"	24'-0"	24'-0"
Ⓓ BAY WIDTH	60'-0"	58'-0"	54'-0"		43'-0"	41'-0"	39'-0"
90° PARKING IN PARKING STRUCTURE							
Ⓐ STALL WIDTH	8'-6"	N.A.	N.A.		8'-6"	N.A.	N.A.
Ⓑ STALL DEPTH	17'-0"	N.A.	N.A.		17'-0"	N.A.	N.A.
Ⓒ AISLE	26'-0"	N.A.	N.A.		26'-0"	N.A.	N.A.
Ⓓ BAY WIDTH	60'-0"	N.A.	N.A.		43'-0"	N.A.	N.A.
COL. SPACING	58'-0"	N.A.	N.A.		41'-0"	N.A.	N.A.

* CONSULT HANDBOOKS FOR DIAGONAL PARKING LAYOUTS. (E. G.: ARCHITECTURAL GRAPHIC STANDARDS OR HANDBOOK OF LANDSCAPE ARCHITECTURAL CONSTRUCTION)

Accessible Spaces Without Curb



Access Through Parking Area



(When existing site conditions do not leave room for sidewalk.)

4. Accessible Parking

a. The rules and regulations of the Architectural Access Board (AAB) of the Commonwealth of Massachusetts apply to the modernization or expansion of commuter rail parking facilities, including surface lots and garage structures. Federal regulations also require accessible parking be provided at these facilities.

b. The MBTA Guide to Access addresses accessible parking at commuter rail stations. Accessible parking spaces must comply with Section 23 of the Rules and Regulations of the Architectural Access Board of the Commonwealth of Massachusetts and Section 4 of the Americans with Disabilities Act Accessibility Guidelines.

c. Provide accessible parking spaces as follows:

Total No.Parking Spaces	Required No. Accessible Parking Spaces
1-25	1
26-50	2
51-75	3
76-100	4
101-150	5
151-200	6
201-300	7
301-400	8
401-500	9
501-1000	2% of total
1001 & over	20 + 1 for each 100 over 1,000

Note: One in every eight accessible spaces, but not less than one, shall be served by a minimum 96 in. access aisle and be designated "van accessible" as required by ADAAG 4.6.4.

Where there is more than one parking lot provided on the same side of the track, it is acceptable to place all accessible parking spaces in the parking lot closest to the platform. However, in such case, the total number of accessible spaces must be computed on a lot by lot basis and added together. They may not be computed from the total number of spaces in the lots. Provide signage at the auxiliary lots to indicate where the accessible parking spaces are located.

Where multiple lots are provided on both sides of the track, a proportionate number of accessible parking spaces must be placed on both sides of the track. If this is not possible, a variance must be obtained from the Massachusetts Architectural Access Board. Where there is more than one lot, the number of accessible parking spaces is calculated on a per lot basis.

5. Gradients

   a. The absolute maximum parking lot gradient is 5% (approx. 5/8" per foot). The absolute minimum acceptable gradient is 0.5% (approx. 1/16" per foot); the preferred minimum is 1% (approx. 1/8" per foot).

      Where an accessible route occurs within the parking area, the maximum slope is 5% with a maximum cross slope of 2% except at aisles between accessible spaces.

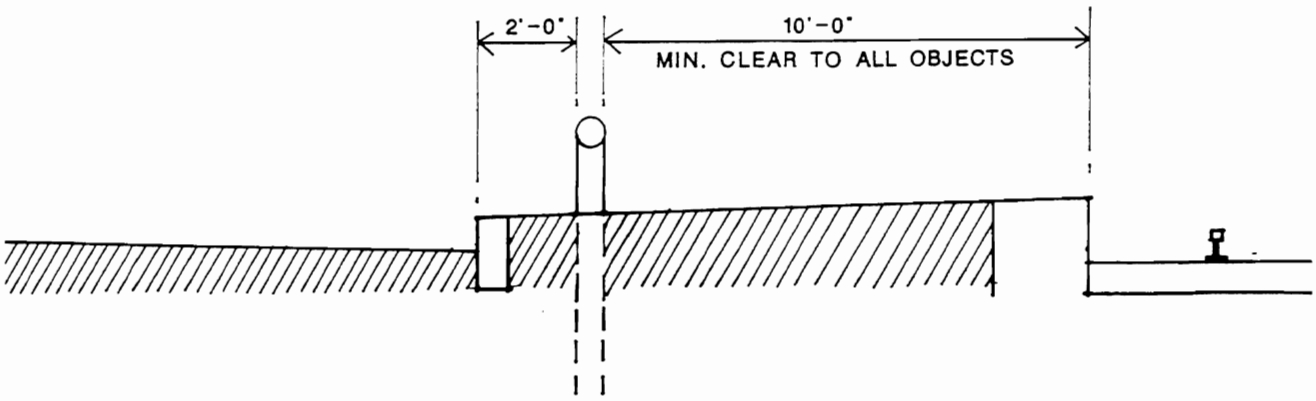
   b. Crown the pavement in each parking bay at the center and pitch to the outside edges to avoid water ponding within aisles where pedestrians will walk.

6. Clearances

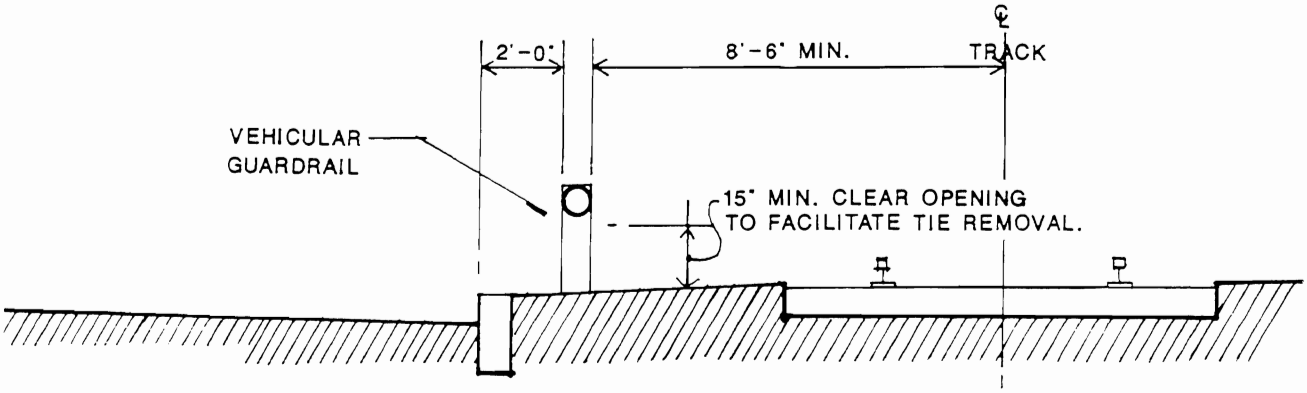
   a. To allow for vehicle overhang, the minimum clearance between the inside face of curbing in a parking lot and any object (such as signs, light poles, trees, fences and barrier walls) is 2'-0".

   b. Where parking is adjacent to track without a platform, provide vehicular guard rail mounted with chain link fence at a minimum of 8'-6" from the center line of track. Where vehicular guard rail is located less than 12'-6" from track centerline, provide a 15" clear space under the guard rail to facilitate cross tie replacement.

Typical Minimum Clearances, Low Platform

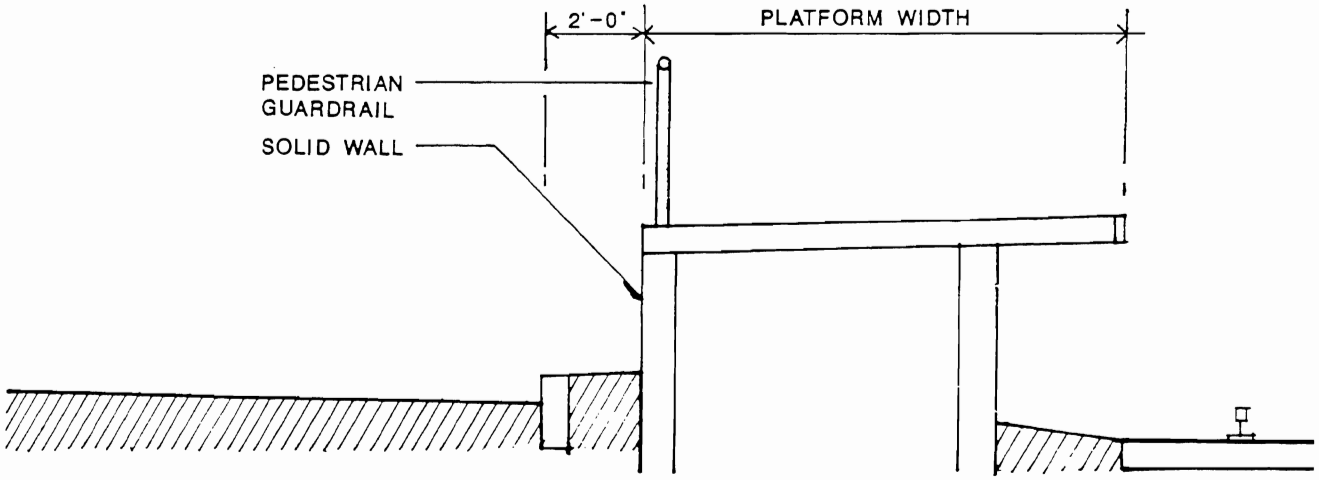


Minimum Clearance at Track, No Platform



NOTE:
WHERE RETAINING WALLS OCCUR ADJACENT TO TRACK, PROVIDE A MINIMUM CLEARANCE OF 12'-0" FROM CENTERLINE OF TRACK FOR REMOVAL OF TIES.

Typical Minimum Clearances (Platform More Than 8" Above Adjacent Surface)



NOTE:
FOR HIGH LEVEL PLATFORMS WITH SIDE PANELS WHICH ARE EASILY DAMAGED, PROVIDE A RAISED CURB 2'-0" AWAY FROM THE SIDE OF THE PLATFORM.

7. Pedestrian and Traffic Islands

   a. Avoid islands since they make snow removal more difficult, increase cost, and complicate drainage. Provide painted islands at the end of bays; raised islands impede snow removal.

   b. General Guidelines (if needed)

      (1) Islands should be a minimum of 4'-0" wide.

      (2) Use long islands perpendicular to parking stalls only when necessary for grading or circulation. Provide 8' to 10' wide breaks at every other parking bay (approx. 120' intervals) to allow for plowing and pedestrian access.

      (3) Avoid curbed inside corners since they make plowing difficult, trap debris and increase the number of drainage structures needed.

F. Use of Landscape Buffers

1. See Chapter 6 for specific design criteria governing the appropriate use of landscape buffers. In general, the Authority prefers to minimize unnecessary landscaping at commuter rail stations.

2. Where appropriate, lay out parking lots to preserve significant natural features--specimen trees, natural berms, outcroppings, etc--which may enhance the visual characteristics of the site. Such features should not detract from the operation, security, and capacity of the lot.

3. Lay out parking areas to leave sufficient space at the perimeter of the site to provide a buffer from surrounding neighborhoods or other sensitive receptors.

G. Use of Barriers

1. Use barriers in station parking areas to channel vehicular and pedestrian traffic, contain water run-off, and, in certain instances, limit pedestrian access to the site. Barriers should be used to maintain a safe separation between platform and vehicular circulation and parking. Typical barriers include curbing, guard rail, bollards,and fencing. (Conditions which govern the use of barriers are described below.)

2. Types of Barriers:

   a. Curbing

      Curbing is the preferred method of defining the limits of a parking lot. Use curbing to control water run-off, to separate

pedestrian and vehicular traffic, and to confine vehicle movements.

Granite is preferred as a curb material (7" maximum vertical reveal). Consider sloped granite as an alternative to vertical granite, but do not use sloped granite in areas of pedestrian circulation. Existing on-site granite curbing may be reused where possible.

If the lot can be easily drained to nearby ditches curbing may not be desirable. Guard rail or bollards should be used to confine vehicles to the paved lot where no curbing is provided.

Do not use the railroad right of way ditch for drainage of the parking area.

b. Vehicular Guard Rail

Vehicular guard rail is used to confine vehicle parking to specific areas. Under certain conditions, it is advisable to provide both curbing and guard rail (or bollards) as a secondary safety barrier (e.g. at the edge of an embankment).

c. Bollards

Use bollards for the same purposes as guard rail. However, bollards allow the free flow of pedestrians between them. Bollards interfere with snow plowing operations requiring either hand shoveling or the use of small machines. Therefor, their use should be minimized to short segments only where necessary.

d. Pipe Rail

Pipe rail may be used for pedestrian guardrails and as a means of channeling pedestrian movements. Typical applications occur along the back face of platforms with vertical drops in excess of 8", along the top side of retaining walls, and at stairs and ramps. Consult the pedestrian guardrail section of this chapter for design criteria.

e. Fencing

Use fencing to limit pedestrian access to the site for safety and security reasons. Fences adjacent to roadways and/or parking lots should be set back and protected by curbing or vehicular guardrail to allow for vehicle overhangs and the storage of plowed snow. Provide curbing or vehicular guardrail.

f. Inter-track Fencing

Inter-track fencing is chain link fence installed between tracks to prevent pedestrians from crossing the tracks except at designated locations.

Inter-track fencing should 4'-0" high and extend a minimum distance of 200'-0" beyond the ends of the platforms. Consult Standard Plan No. 3204 for design criteria.

H. Parking Area Drainage Requirements

1. Authority policy is to install a storm drainage system in all new parking lots as well as those being upgraded.

   Only small parking lots (generally those with under a twenty-five vehicle capacity) surrounded by porous soil capable of absorbing water run-off form the parking area may be designed without a storm drainage system. Do not drain toward the track right of way under any circumstances.

2. Storm drainage systems should conform with the Massachusetts Department of Public Works standards. See the Landscaping subsection for a description of drainage system design guidelines.

I. Parking Fee Collection

1. At stations where a parking fee is to be collected, the Authority uses a central coin-slot system to collect parking fees.

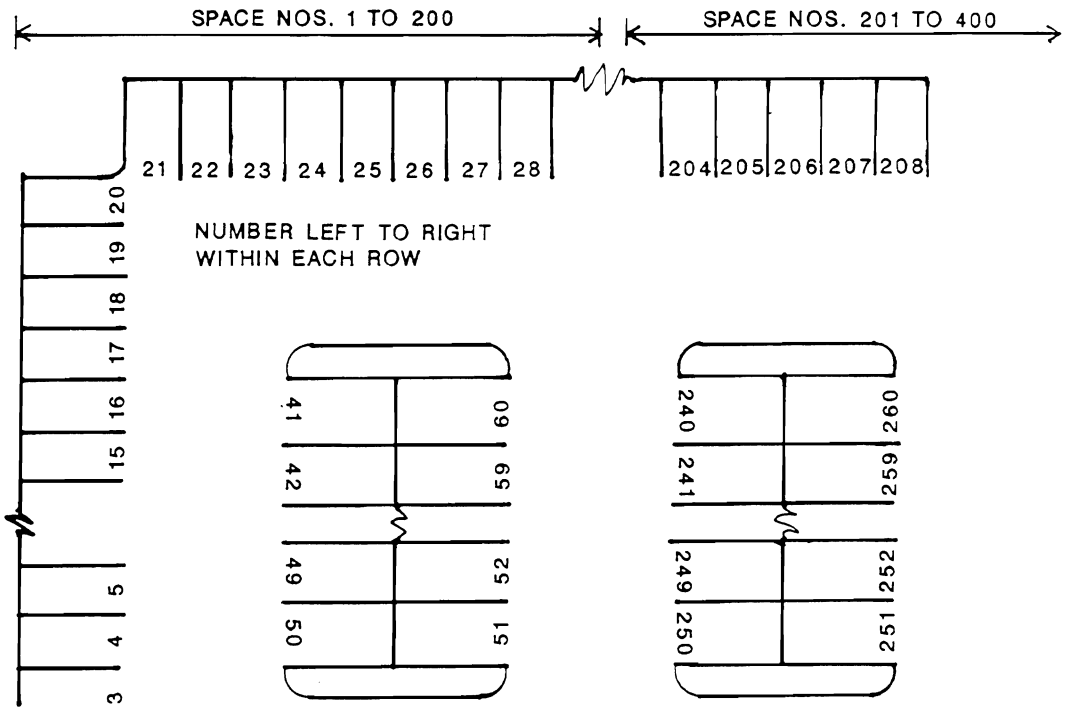
   a. The central coin-slot system consists of a centralized parking fee depository with numbered coin slots which are keyed to numbered spaces in the parking lot. The user deposits the fee as he or she walks to the platform. (See diagram following)

      Location of the central collection box shall be determined by the Authority . Where possible, the central collection box should be highly visible and should be located under a canopy and on the same side of the track as the parking in a central area adjacent to the inbound platform. In larger parking lots, divide the lot into numbering zones of not more than 200 spaces. (See diagram following)

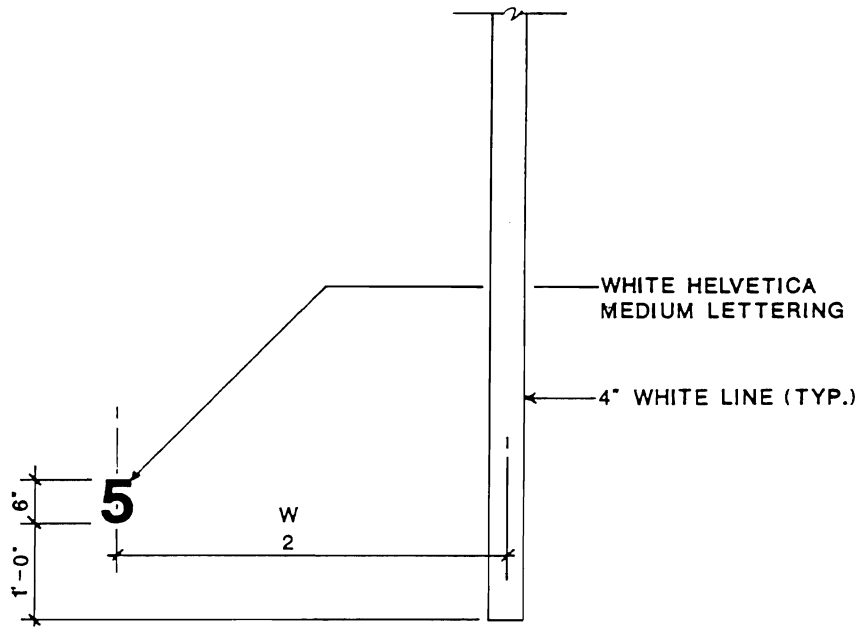
      See MBTA Guide to Access for guidelines on how to make collection boxes accessible to the physically disabled. Collection boxes must be located on an accessible route.

b. Parking spaces should be clearly marked and numbered consecutively.

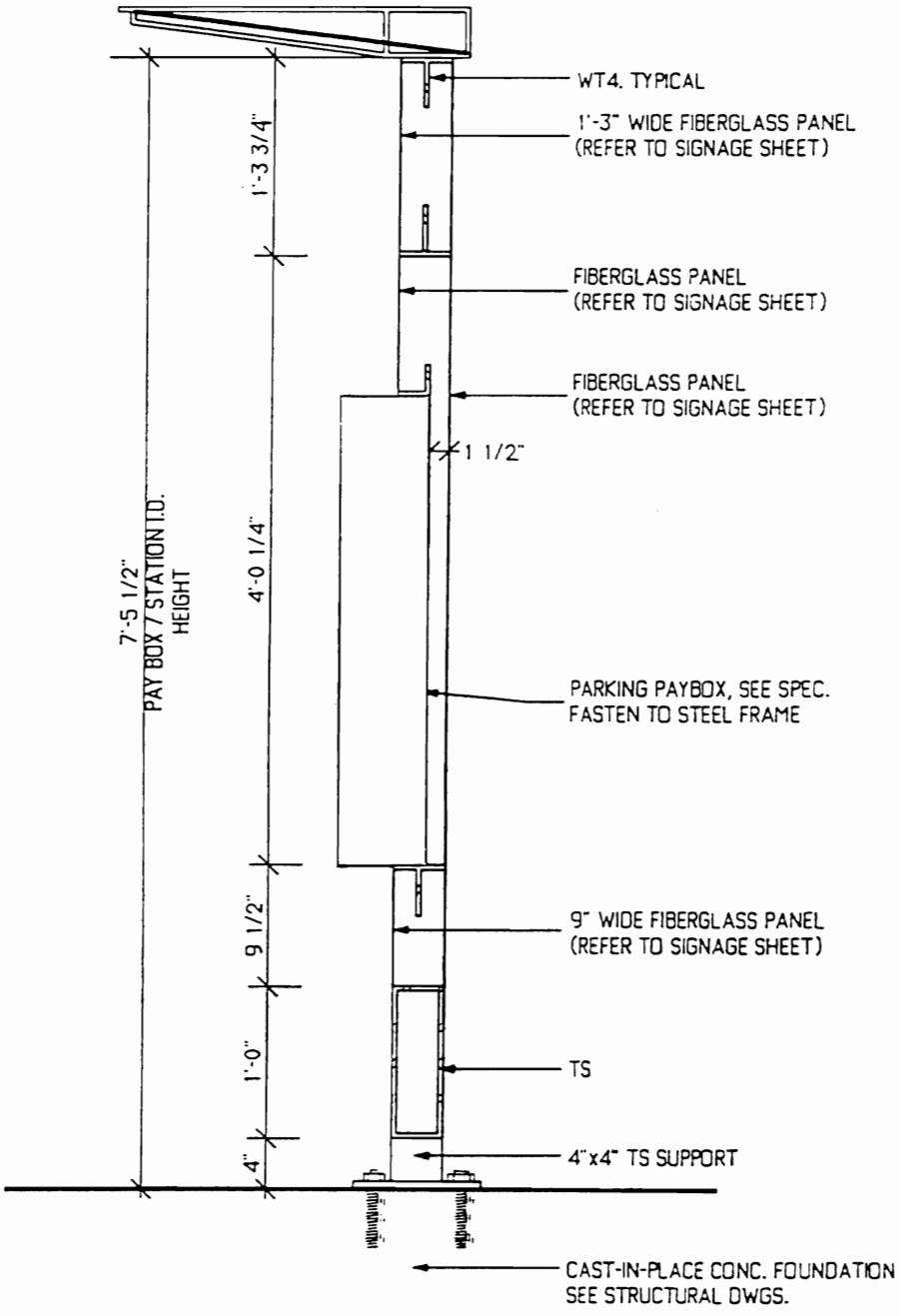
Parking Space Numbering For Fee Collection



Example of Space Numbering



Elevation of Cash Box Panel



IV. REFERENCE STANDARDS

Consult the following reference standards for more information:

- Architectural Graphic Standards, by Ramsey and Sleeper, Edited by the American Institute of Architects, Published by John Wiley and Sons.
- Handbook of Landscape Architectural Construction
- Mass D.P.W. Standard Specifications for Highways and Bridges (1988 Ed.)
- MBTA Guide to Access
- MBTA Standard Specifications
- A Policy on the Geometric Design of Highways and Streets, Published by the American Association of State Highway and Transportation Officials.

V. PREFERRED MATERIALS

A. Paving Materials

Material	Comments
Bituminous	The Authority prefers to use bituminous Concrete to pave parking lots because it is durable, inexpensive, and easily repaired. See details Mass DPW Standard Specifications for Highways and Bridges.

B. Curbing Materials

Material	Comments
Granite	The Authority prefers to use granite curbing in parking lots because it resists damage from salt and snowplows.
Bit. Conc. Swales	Used to channel runoff to a catch basin when a more substantial curb is not required; formed integrally with paving. Often used in combination with guard rail.

C. Barriers

Material	Comments
Vehicular Guard Rail	Used to confine vehicular traffic to designated areas. May be either galvanized steel highway guardrail or heavy duty steel

	pipe rail. See Mass DPW Standard Specifications for Highways and Bridges.
Bollards	Used to confine vehicular traffic while allowing pedestrians to pass through. Use concrete-filled galvanized steel pipe. Height varies: 2'-0" when used with a curb 2'-6" when used to define the edge of a parking area 4'-0" when used as a barrier (e.g. to close off a road)
Fencing	Used to limit access to a restricted area for security reasons, or to channel pedestrian traffic. Typically galvanized steel wire mesh. MBTA Standard Specifications.
Pipe Rail/Guardrail	Used to channel pedestrian flows and to minimize the possibility of an accidental fall from an elevated walking surface. Consult section on pedestrian guardrail for design criteria.

D. Striping Materials

Material	Comments
Roadway Marking Paint	Use roadway marking paint within the station to delineate traffic lanes, parking spaces, parking space numbers, crosswalks, etc. See Mass DPW Standard Specifications for Highways and Bridges.

CHAPTER 2
CANOPIES AND PLATFORMS

I. INTRODUCTION

This section establishes design objectives, guidelines, and design criteria for the construction of new shelters and platforms at commuter rail stations. Both high and low level platforms are discussed.

The objectives and guidelines presented below are a response to user needs and to the practical operating and maintenance requirements of the Authority. Surveys have indicated that shelter is the most important feature of a station to the commuter rail user.

II. DESIGN OBJECTIVES

Comfort, safety, efficiency, and durability are the principal objectives to be considered in the design of platforms and shelters at commuter rail stations. The station shelters function primarily as a protection from the elements. However, they should be designed to include good lighting, visibility from both the inside and out, as well as multiple means of egress to enhance the users sense of safety. These objectives should also address specific issues of maintenance and snow removal.

III. DESIGN GUIDELINES

A. PLATFORMS

1. LOCATION

   a. All commuter rail stations should have a paved platform(s).

   b. A major consideration in determining platform location is achieving maximum visibility of the platform from the surrounding area for security reasons. Access should be as direct as possible from the surrounding area and parking lot.

   c. Platforms should be located to avoid conditions where a stopped train or a grade crossing gate will back-up local traffic on the crossing street (see illustration). The preferred platform arrangement at stations adjacent to grade crossings is a split configuration in which trains pull beyond the grade crossing far enough to clear the crossing signal circuit. Where this arrangement is not feasible, the preferred alternative is a configuration locating both platforms on the outbound side of the crossing. This arrangement clears the crossing during the evening period when traffic is typically heaviest.

   d. Locate platforms so that trains held at interlocking signals can load/unload.

   e. An important consideration in the location of platforms is the topography and access for maintenance and snow removal equipment.

It is not desirable to locate platforms where the right-of-way topography is severe, since this will require the construction of retaining walls that will increase the cost per linear foot of the platform.

2. SAFETY

a. Platforms should have adequate space for passengers gathering on the platform and waiting in line to board the train during peak times.

b. Platform areas should be well lighted and drained and should have a slip-resistant surface.

c. The track side edge of the platform must have a tactile warning strip.

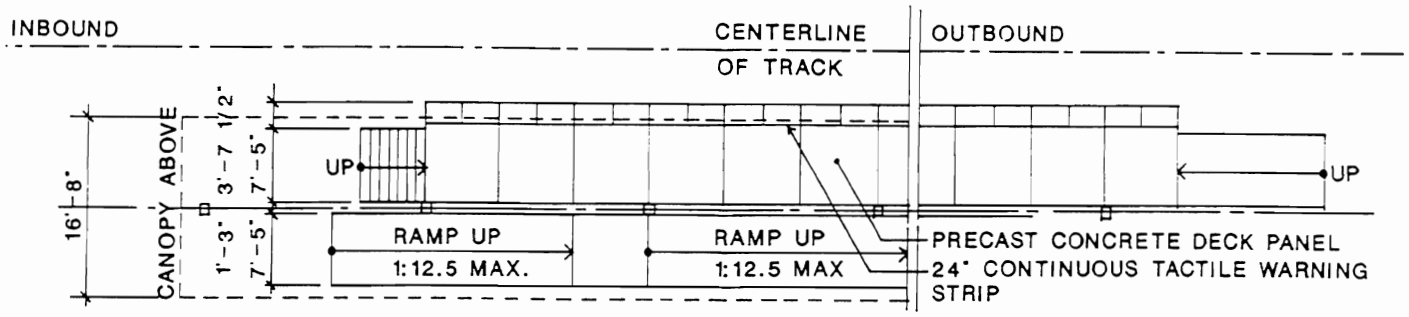
d. Minimize the number of obstructions on the platform to insure maximum visibility of the platform by the train crew, as well as to insure good pedestrian flow and access of maintenance vehicles.

3. EFFICIENCY

a. Access to platforms should be highly visible and direct from drop-off/pick-up points and pedestrian walkways.

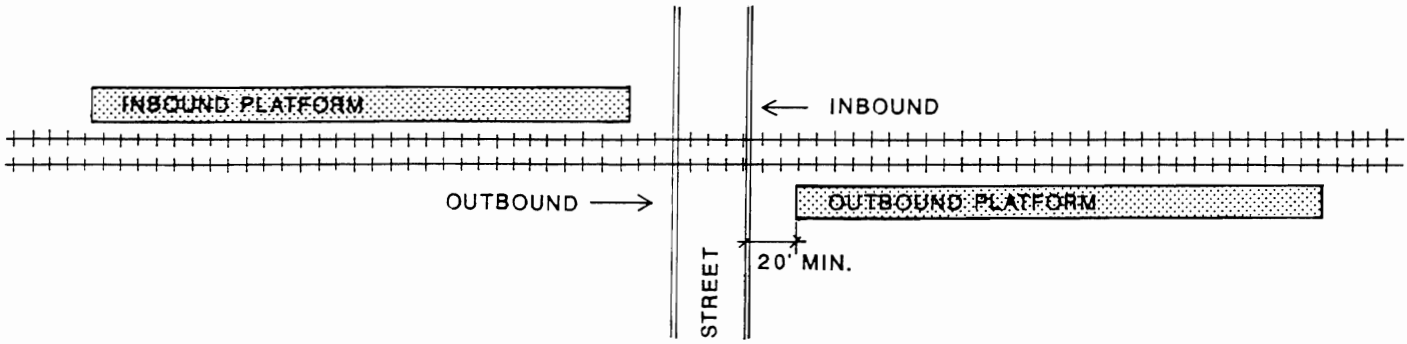
b. Platforms should be free of columns, utility poles, and other objects impeding free pedestrian flow.

Platform Location Diagram

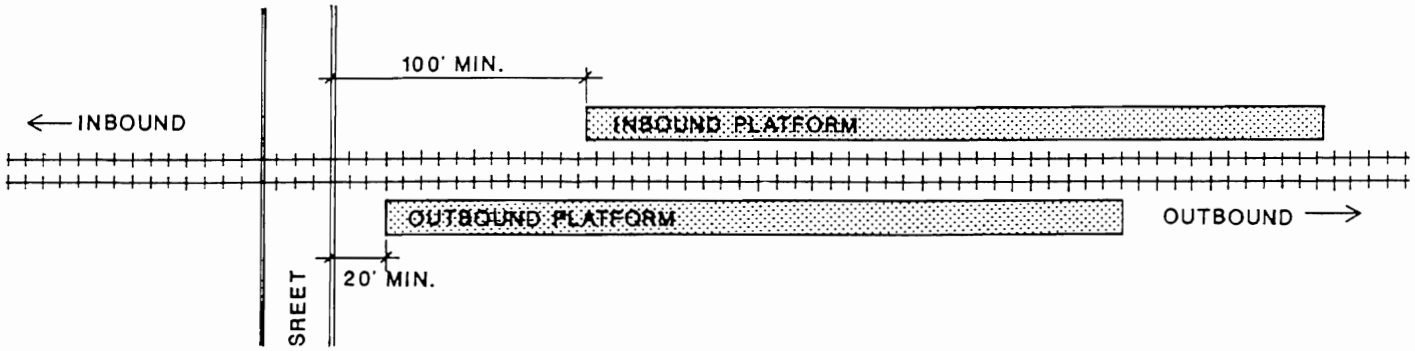


Note: Coordination of track alignment and profile with the precast concrete station platform is critical! Track alignment and profile must be surveyed and verified by Massachusetts licensed surveyor.

Preferred Arrangement of Platforms at Grade Crossing



Alternative Arrangement of Platforms at Grade Crossing



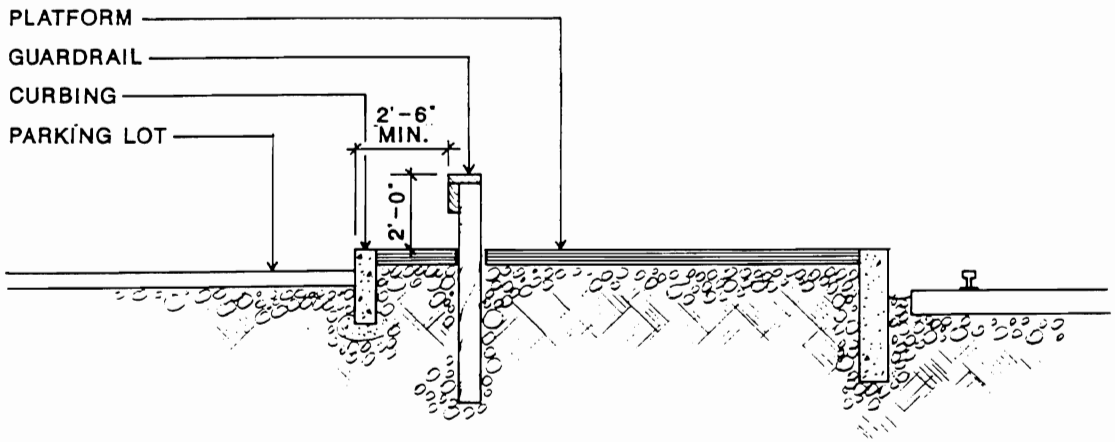
4. USE OF BARRIERS

a. Provide barriers along the back face of a platform under the following conditions:

- Where there is a sharp drop in elevation exceeding 2'-0".
- Where active freight tracks are located behind the platform. Random pedestrian crossing of these tracks is a potential safety hazard that can be minimized trough the use of a barrier that channels pedestrian movements to specific points.
- Where a parking lot abuts the platform. Under this condition the barrier serves as a primary or secondary deterrent to vehicle access to the platform. When a barrier system such as a guard rail is used in this situation it may also double as a sitting area for waiting passengers, as the accompanying detail illustrates.

b. Typical barrier systems that might be used along the back face of a platform include pipe rail, guard rail, and wire mesh fencing. The choice of system will depend on factors such as the magnitude of the safety problem (i.e. protecting a person from a ten foot fall or it may simply be a reminder to cross tracks at a specified location) and specific project funding limitations.

Detail of Barrier System Limiting Vehicle Access to Platform Area



B. SHELTERS

1. GENERAL

   a. Canopy structures should provide overhead and wind protection along portions of the platform(s). When combined with a vertical windscreen panel, the canopy provides the user a moderate amount of protection from rain, snow, and wind. At the same time, it is a relatively economical and low-maintenance form of shelter.

   b. It is not economically feasible to provide heat in this type of open-air shelter.

2. LOCATION

   a. New shelters should be located on or adjacent to the platform in areas that are the most visible from adjacent streets and neighborhoods. For low level platforms, canopies must be provided for the protection of access paltforms and ramps. Generally a second canopy should be provided at a central location on the low platform. High level platforms may only require a single shelter, however the location(s) must provide for the protection of any access ramp(s) serving the platform(s).

   b. New shelters should also be located on the most directly accessible route from the site entrance(s) to the platform when this location does not conflict with the high visibility guidelines described above.

   c. New shelters should be designed and located in a manner that does not obstruct the visibility of the conductors in the approaching trains.

3. CONVENIENCES

   A detailed description of the types of conveniences that should be provided appears in the Comforts and Conveniences chapter.

4. LIGHTING

   Lighting design guidelines for buildings and canopies are presented in the Lighting chapter of this manual.

C. ACCESSIBILITY FOR SHELTERS AND PLATFORMS

1. All shelters and platforms should be readily accessible via primary site entrance/exit.

2. Persons with disabilities must have full access to all shelters and platforms, as specified in the Rules and Regulations of the

Massachusetts Architectural Access Board, Americans with Disabilities Act Access Guidelines, and the MBTA Guide to Access. For 'key' station sites, refer to ADAAG Section 6, the MBTA Guide to Access and consult with the Authority for specific requirements. Some of the requirements pertaining to shelters are summarized below.

a. The approach to the primary entrance/exit of all shelters shall be uninterrupted by steps. If there is a change of elevation, a ramp will be provided in conformance with the ramp design requirements described in the Circulation subsection of this manual.

b. Access should be as direct as possible from the surrounding area and parking lot to platform.

c. New stations shall have full length high level platforms.

IV. DIMENSIONAL GUIDELINES

A. PLATFORMS

1. ELEVATION

a. The standard height of low level platforms is 8" above top of rail on non-super-elevated tracks; the horizontal clearance between the centerline of track and the track-side face of a low-level platform curb shall be 5'-1" on tangent track. Mini-high level platforms are required on the outbound end of low level platforms.

b. The standard height of high level platforms is 4'-0" above top of rail on non-super-elevated tracks; the horizontal clearance between the centerline of track and the track side of a high level platform shall be 5'-7" on tangent track. This horizontal dimension applies only to locations where freight clearance is not a problem.

c. Mini-High level platforms requiring additional freight clearance shall be equipped with a "flip-up" platform edge (Consult the Authority for details of this special edge detail).

2. LENGTH

a. Unless otherwise directed, platforms must accommodate a 9 car train. On low platforms, the access platform (mini-high) is included in the length of the platform.

b. The length of outbound platforms should be equal to the length of the longest train serving the station plus a 20'-0" allowance for a train overshooting or undershooting the platform. The intention is to provide disembarking passengers the opportunity

to exit the train directly from any coach. Typically, trains are 2 to 12 coaches in length. The following formula can be used to calculate outbound platform length:

- Number of coaches on longest train x 85'-0" + 20'-0"= length of platform. (In general, design for 9 cars unless directed otherwise).

c. The length of the inbound platform may be shorter than the longest train. It is standard MBTA practice to run the locomotive always on the "country" or outbound end of the train set. As a result, the engineer on an inbound train in the control cab of the front car of the train set is always blocking passenger access to the front door of the first car. However,the rear door of the first car remains accessible. The inbound platform may therefore be 55'- 0" shorter than the length calculated by the above formula for the outbound platform.

d. The absolute minimum platform length is 2 coach modules + 20'-0" or 190'-0".

3. WIDTH

a. Platforms should be sufficiently wide to comfortably accommodate peak loading requirements. The width is also affected by line, available space, and ridership only at short platforms. Adequate comfort levels for waiting and boarding movements can be achieved at a maximum density of 5 sq. ft. per person. As the following example illustrates, the maximum density level will rarely be approached at commuter rail stations.

- Assume a peak train boarding level of 200 people (about 1/3 system stations average this number or more). At a density of 7 sq. ft. per person, the space requirement is 1,400 sq. ft. Assume an absolute minimum length platform that is 190'-0" long and 10'-0" wide. The effective width of the platform (allowing for 2'-0" safety clearance at the track side face of the platform) will be 8'-0"and the effective area of the platform will be 1,520 sq. ft. or in excess of the 1400 sq. ft. minimum. With platforms generally in the range of 700-800 feet in length, standing/boarding capacity is normally of no concern.

b. The preferred platform width is 12'-0"; 10'-0" is acceptable and 8'-0" is the absolute minimum width.

c. For reasons of economy, long platforms may be tapered at the ends to a minimum width of 8'-0".

d. The preferred island platform width is 22'-0" for a minimum of

1/2 the platform length. Ends of island platforms may taper to a minimum width of 12'-0".

4. GRADIENT

Platforms should comply with accessibility regulations which state that the cross slope (the slope perpendicular to the direction of the tracks) can be a maximum of 2%; or not exceeding 1 ft. of rise for every 50 ft. of run.

5. WARNING STRIPE

All platforms must have a 24" yellow tactile warning strip running the length of the platform to comply with ADA access guidelines. Tactile warning strip should not be installed at low level platform ends.

B. SHELTERS

1. Size

a. The sheltered area at each station should accommodate approximately sixty percent of the passengers boarding at times of peak volume. This figure reflects two considerations: first, that about twenty percent of the passengers either wait in their automobiles or arrive at the last minute and do not use the shelter. Secondly, economic considerations do not allow the Authority to fully accommodate peak period needs.

b. The optimal size of the platform canopy should be determined as follows:

- Assume no shelter is currently at the station.
- Number of passengers using peak volume train = 100.
- Design capacity of shelter = 60 % of 100 = 60
- Net area required = 60x7 sq. ft. = 420 sq. ft.
- Gross area required = 420x1.05 = 447 sq. ft. or approximately 400-450 sq. ft. of shelter.

2. MINIMUM CLEARANCES

a. The preferred minimum horizontal clearance between vertical support for a canopy and the track-side edge of platform is 10'-0". The absolute minimum is 8'-0".

b. The minimum horizontal clearance between a canopy roof overhang and the centerline of any track is 7'-6" (8'- 6" on the Framingham/Worcester Line) except where the canopy is at a height that overhangs operating equipment. The minimum clearance from the track centerline to face of canopy columns, wall, or other obstruction is 15'-1".

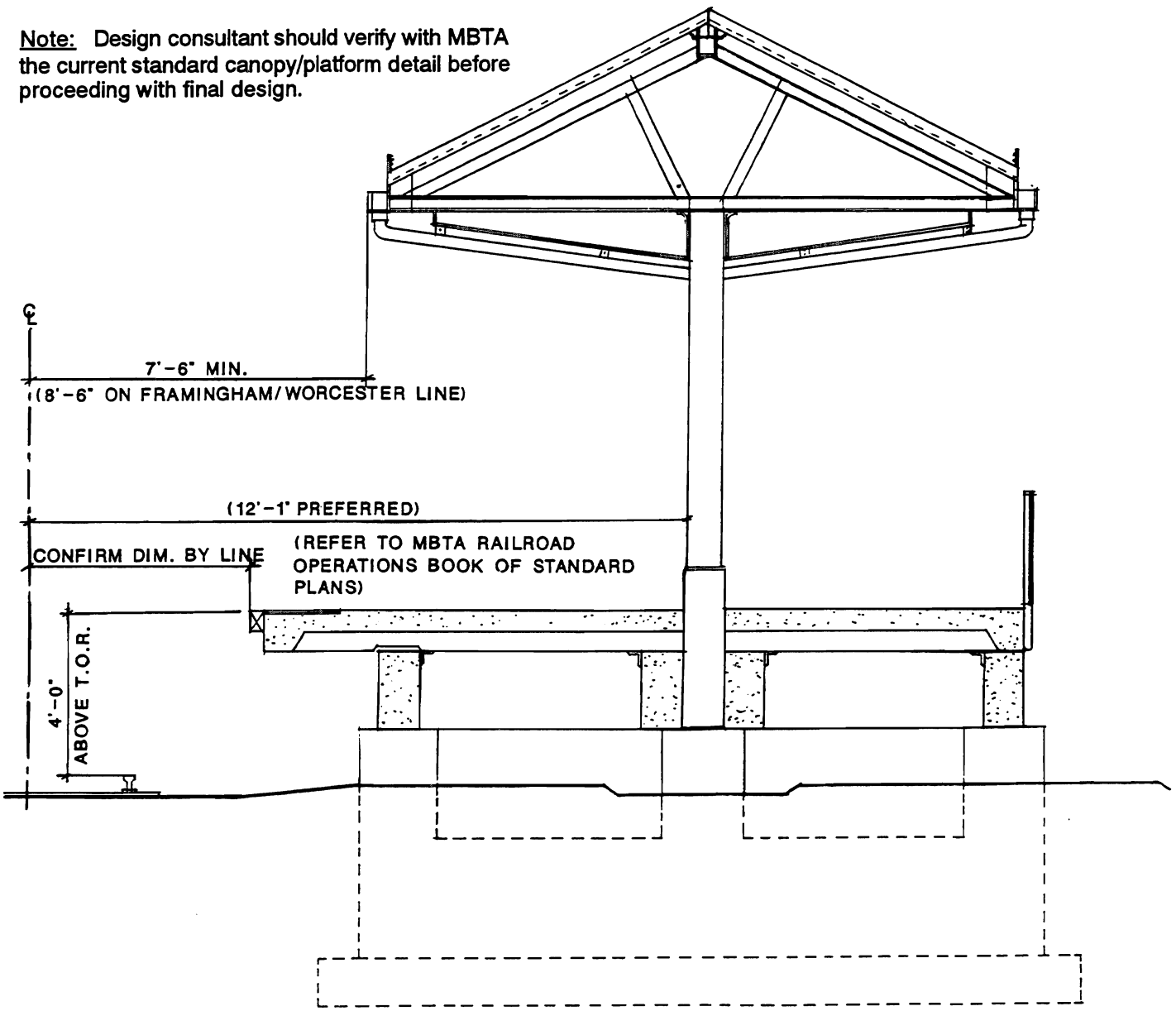
c. The minimum clearance between the floor and the vertical panel in a canopy is 6". This clearance prevents the accumulation of leaves and debris in corners of the canopy.

d. The vertical clearance from the top of rail to the bottom face of the canopy adjacent to track is 12'-1".

e. Refer to MBTA Railroad Operations Book of Standard Plans, Roadway and Track for further clearance information, drawing No. 1013 in particular for station requirements.

Detail of Minimum Shelter Clearances

Note: Design consultant should verify with MBTA the current standard canopy/platform detail before proceeding with final design.



V. DESIGN CRITERIA AND DETAILS

A. PLATFORM

1. PAVING MATERIALS

High level platforms shall be architectural precast concrete. Please refer to structural drawings provided by the Authority for reinforcing, connections, and bearing. Low level platforms are constructed of bituminous concrete with timber or pre-cast concrete curbing. Design and construction of all work shall conform to the following:

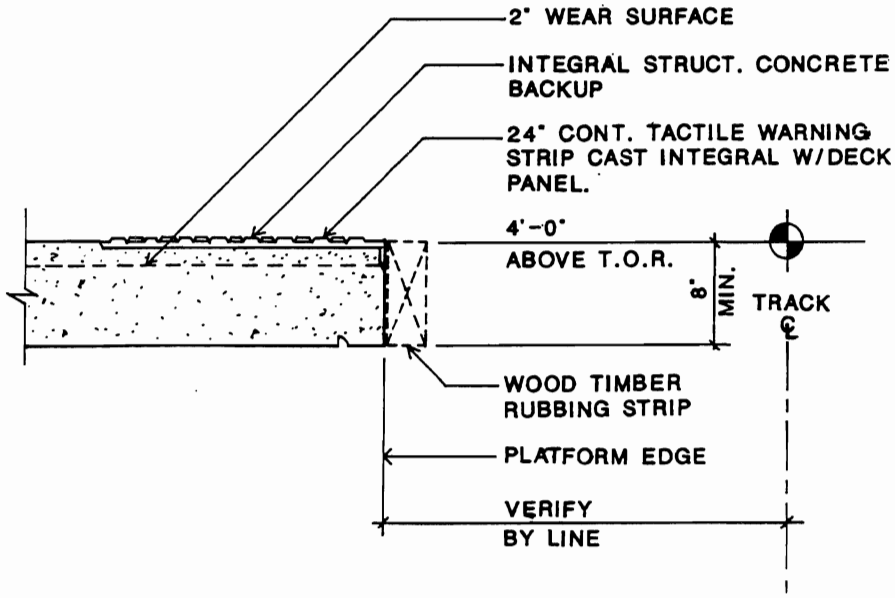
- MBTA Standard specifications including special provisions
- Massachusetts Building Code, 5th edition
- Americans with Disabilities Act Accessibility Guidelines (ADAAG)
- Rules and Regulations of the Architectural Access Board (AAB) of the Commonwealth of Massachusetts

In case of conflict between the codes, standards, regulations, specifications, general notes and/or manufacturer's requirements use the most stringent provisions.

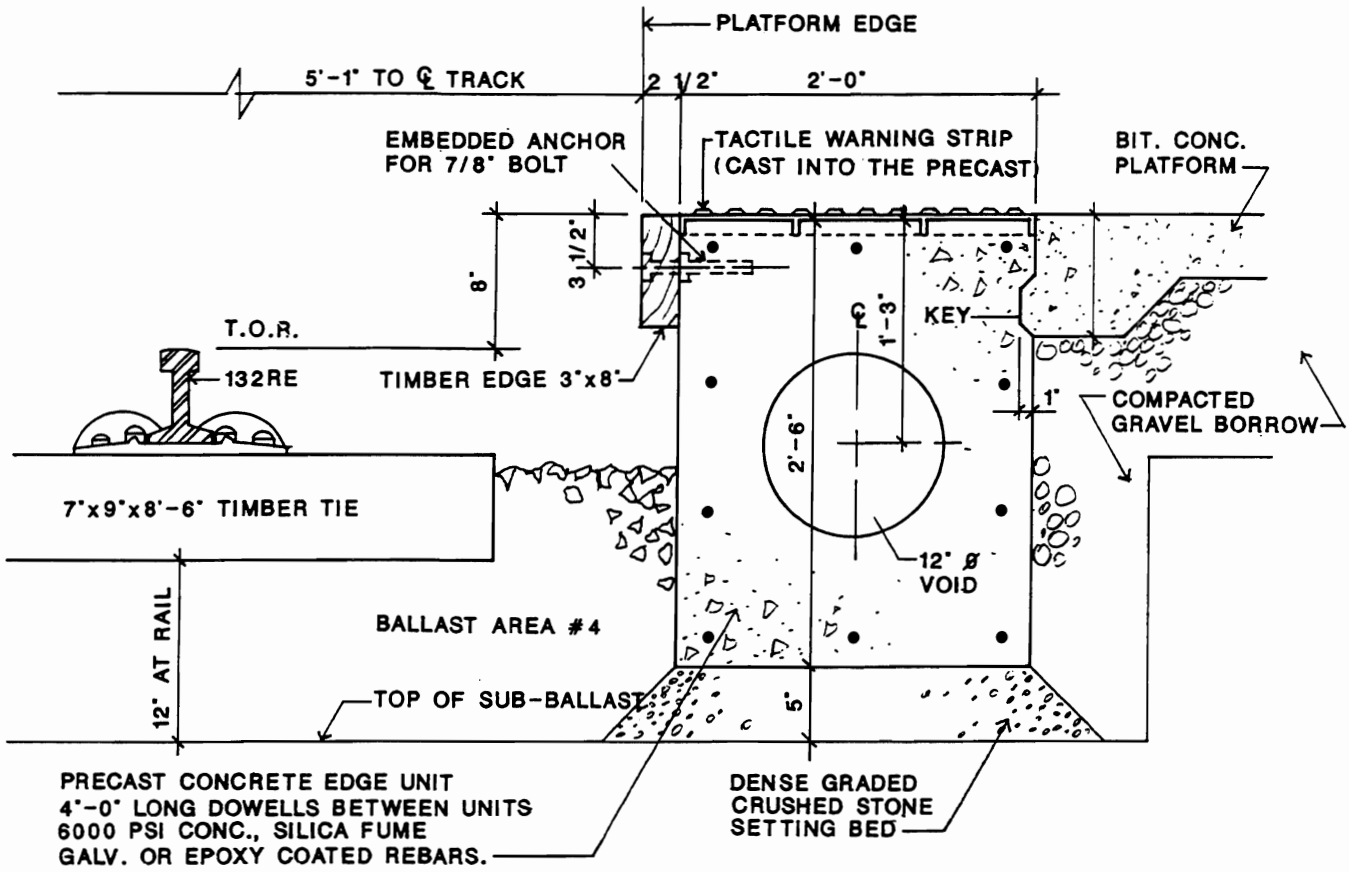
2. PLATFORM CURBING WITH TACTILE WARNING

Platform curbing is essential to the creation of a safe and durable transition between the train and the platform. All platforms must be curbed with a 24" tactile warning strip. See accompanying details for precast and timber curbing

Precast Concrete Edge for Commuter Rail High Platforms



Precast Concrete Edge Unit for Commuter Rail Low Platforms



3. BARRIERS

a. Pipe Rail: should be used to channel pedestrian movements, not as a safety barrier. Typical details are presented in the Circulation chapter.

b. Guard rail: should be either galvanized steel, heavy timber, or either type of rail used in conjunction with concrete posts. Steel guard rail should conform with the MDPW Standard Specifications for Highways and Bridges, Division III, Section M8. Heavy timber guard rail is typically less expensive than galvanized steel and should be of a type similar to that described in the Circulation chapter.

c. Fencing: A wire mesh type of fencing may be used in certain platform locations. Standard Authority details for wire mesh fencing are shown in the Circulation chapter.

B. SHELTERS

The MBTA has established design standards that specify the appropriate materials and types of construction that must be used for shelters. This documentation may be obtained directly from the Authority.

CHAPTER 3
LIGHTING

I. INTRODUCTION

This section describes commuter rail station illumination requirements. Station area illumination is a critical factor in the enhancement of the rider's comfort and perception of safety. Therefore, careful consideration to both the quality and quantity of light is necessary.

II. DESIGN OBJECTIVES

Security, visual comfort, compatibility with surrounding uses, efficiency, and attractiveness should be addressed in the design of commuter rail station site lighting.

A. SECURITY

The primary function of lighting is to make the commuter rail station and site safe and secure, as well as visible from surrounding areas.

B. EMPHASIS

Highlighting should be used to emphasize potential hazards, informational signage, and major focal and access points which include:

- Stairs
- Ramps
- Vehicular and pedestrian track crossings
- Platforms
- Pedestrian crosswalks
- Tracks
- Shelters
- Drop-off/pick-up areas
- Building entrances and exits
- Vehicular entrances and exits
- Signage

C. VISUAL COMFORT

To insure visual comfort, station and site lighting should:

- Provide the appropriate level of lighting.
- Provide the appropriate contrast between lighting levels.
- Minimize glare. Light sources should not be located within the normal visual angle of pedestrians or drivers.
- Minimize reflected glare from smooth surfaces, such as signs.

D. COMPATIBILITY WITH SURROUNDING USES

Station and site lighting should not interfere with:

- Adjacent residential neighborhoods
- Train operation and signals
- Operation of vehicles off-site

E. EFFICIENCY

One consideration in the selection of lighting type should be its lifetime cost. This includes the cost of purchase, installation, operation, maintenance, and replacement of lamps and standards.

F. ATTRACTIVENESS

Commuter rail station and site lighting hardware should be:

- Compatible in appearance with the surrounding environment.
- Durable under the following conditions: extreme weather conditions, vandalism, dirt accumulation, and limited maintenance.

III. DESIGN GUIDELINES

A. ILLUMINATION LEVELS

The following illumination levels satisfy the objectives discussed above. However, the designer may deviate from the standards listed below to compensate for specific operating or site conditions.

LOCATION	AVERAGE MAINTAINED FOOTCANDLES
Parking Lots	1-2
Platforms	2-5
Canopies	5-10
Station Buildings	5-10
Shelters	10
Stairs	5-10
Underpasses, Enclosed Overpasses	5-10
Sidewalks and Overpasses	5
Handicap Access Ramps/Parking	5-10

B. OPTICAL CONSIDERATIONS

In the design of station building and site lighting, the contrast between various surfaces within eye contact should be maintained at ratios that will not reduce visual acuity, result in visual discomfort, or cause direct or reflected glare.

1. Contrast Ratios

   The ideal contrast ratio between illuminated areas and adjacent or surrounding areas should be limited to 20:1. In no case should it exceed 80:1. The contrast between emphasis lighting and surrounding surfaces should not exceed a ratio of 3:1. The relative levels of luminance of signs and information panels to adjacent and background surfaces should not exceed a ratio of 5:1.

2. Glare

   Luminaires should be designed and located to prevent the source's full brightness from being visible to the eye within normal viewing angle as shown in the accompanying illustration.

3. Reflected Glare

   The angle of view of a vertical surface should exceed the angle at which light strikes the surface to avoid direct reflections from the source, as the accompanying diagram illustrates.

4. Methods of Control

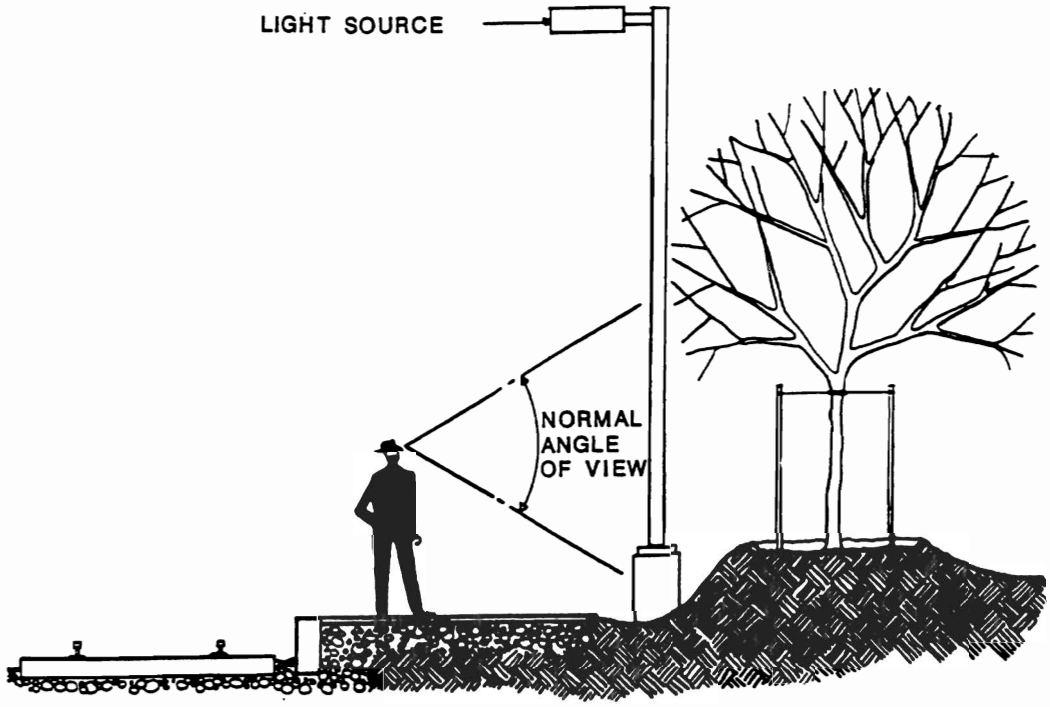
   Contrast ratios, glare, and reflected glare can be controlled through use of the following:

   - Diffusers to moderate source brightness whenever possible.
   - Indirect lighting, such as "wall washing" with light, to control glare and reduce the contrast ratio between a light source and the surrounding environment.
   - Parabolic reflectors within light fixtures to control a light source without sacrificing light intensity on the lighted surface. They are especially useful with High Intensity Discharge (HID) lighting near residential neighborhoods.
   - Contrast ratios and glare can also be controlled by adjusting the location and intensity of the source.

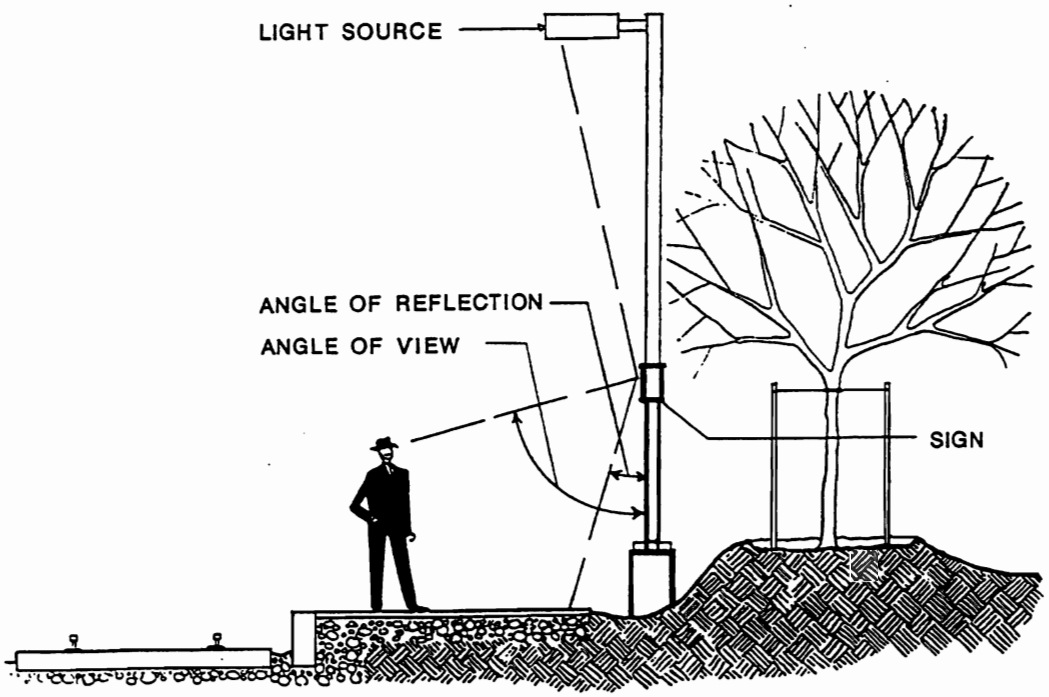
C. EMPHASIS OF HAZARDOUS AND TRANSITION AREAS

Higher levels of light should occur at potential danger or decision areas (stairs, track crossings, street crossings, platform edges, hidden corners, railings, and signage). This illumination should be at least 5-10 average maintained footcandles at the surface being lighted.

Example of Method Minimizing Direct Glare



Minimize Reflected Glare by Insuring That Angle of View Exceeds Angle of Reflection



D. EMERGENCY LIGHTING

Emergency lighting should be limited to the interior of enclosed station buildings and enclosed stairs. The system should have a self-contained battery pack and should be mounted at a height sufficient to prevent vandalism and to provide adequate emergency lighting with a minimum of fixtures.

IV. DESIGN CRITERIA AND DETAILS

A. GENERAL LUMINAIRES SELECTION CRITERIA

Luminaires used at commuter stations should meet the following criteria:

- Function effectively for a minimum of 20 years.
- Resist vandalism, with polycarbonate or high impact acrylic diffusers and vandal-proof access devices such as latches, screws, and locks.
- Minimize maintenance time and costs. Replacement of lamps and ballasts shall be easily accomplished. Lamps and ballasts shall be readily available and standardized to the greatest extent possible. All lenses, diffusers, access devices, and fasteners shall be of the captured type; hinged and removable to provide easy access and prevent loss or damage of parts.
- Contain only non-corrosive materials.
- Function effectively within a -20 to + 110 F ambient temperature range (-28 C to +43 C).
- Provide fixture enclosure that keeps moisture and dust out, but allows heat to dissipate.

B. GENERAL LAMP SELECTION CRITERIA

1. A variety of lamp types is available today. Three factors should be considered in selecting the lamp type.

   - Lumen/watt efficiency of the lamp.
   - Effect of the light source color on the surface color appearance of the surrounding areas and objects.
   - Mounting flexibility.

2. Due to the effect of light source color on surface color appearance, the result of lamp choice on user perception should be considered. A given lamp's lumen/watt efficiency and mounting flexibility should also be considered.

3. The lamp types available are:

   a. High Intensity Discharge

      High Intensity Discharge (HID) is the preferred light source for

commuter rail stations because it is highly energy efficient. HID lamps are point light source, electric discharge lamps requiring ballasts. Starting requires several minutes. The preferred HID lamps are:

- Mercury vapor lamps, which emit a greenish-blue light and cause a perceptible shift in color rendition. They are highly efficient (30-65 lumens/watt) with long rated lives (16,000-24,000 hrs.) and excellent lumen maintenance. Mercury vapor lamps are primarily suited to high bay (over 13'-0" mounting height) applications.

- Metal halide lamps, which produce a white light. Color rendition is as least equal to mercury vapor. Metal halide lamps are smaller in size than mercury vapor lamps, yet produce a substantially greater output of lumens/watt.

- High pressure sodium lamps, which emit a distinctly yellow-orange light and have a very perceptible effect on color rendition. High pressure sodium is the preferred HID lamp because it is the most efficient lamp currently available (approximately 100 lumens/watt). It should be used for lighting large exterior areas such as parking lots and walkways. A typical fixture that might be used in these applications is described in accompanying illustrations.

b. Fluorescent

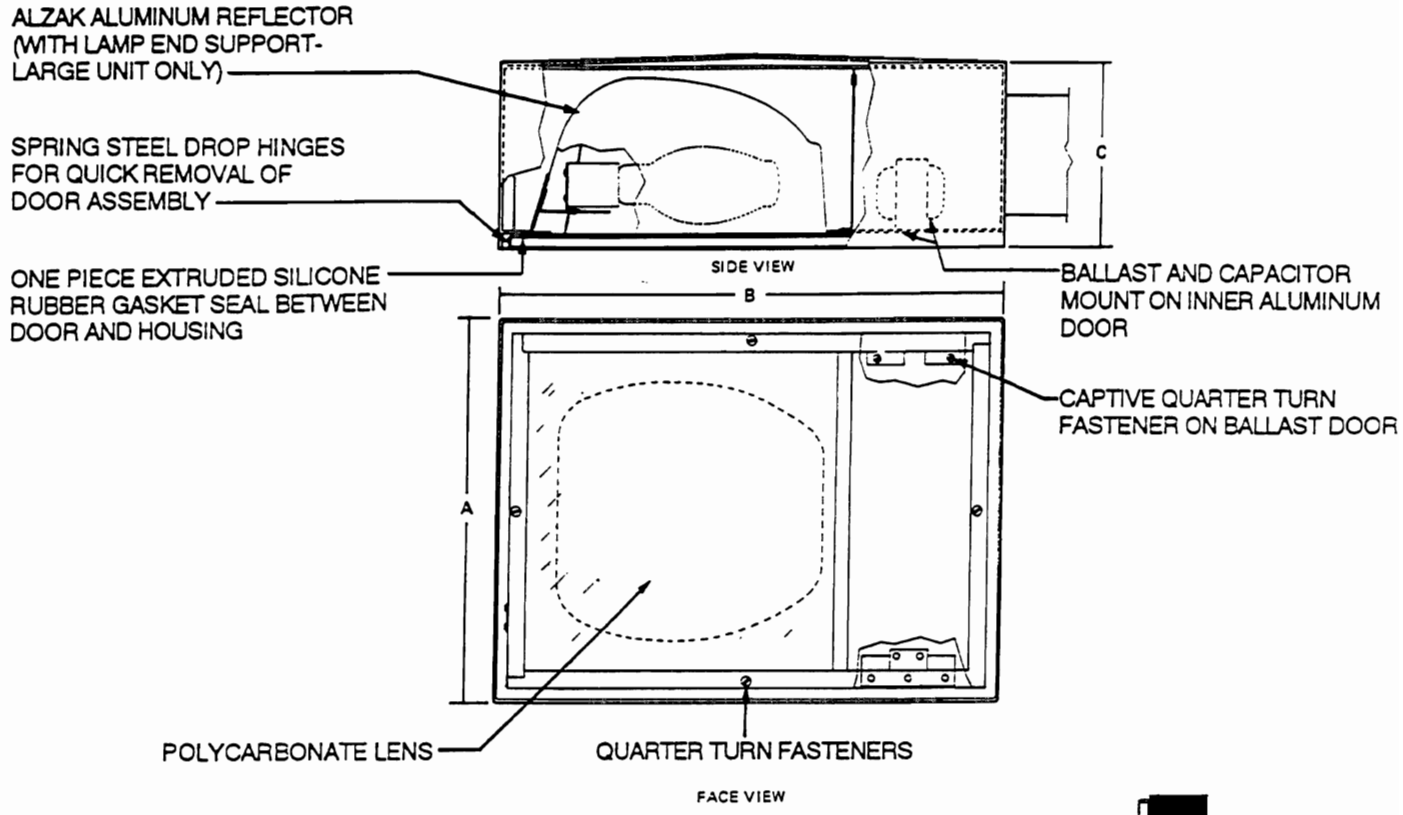
- Available in several colors. Warm white fluorescent lamps produce good color rendition and mix well with incandescent. Cool white lamps tend to dull warm colors and intensify cool colors, but are the most efficient (lumens/watt) fluorescent color. Fluorescent is a linear light source characterized by higher light efficiencies, cooler operating temperatures, and longer life expectancies than incandescent.

- Fluorescent lamps are effective in low and medium level lighting applications due to their efficiency and low source brightness. Fluorescent lamps are appropriate under most interior conditions and preferred over incandescent. They are recommended for lighting under canopies and shelters.

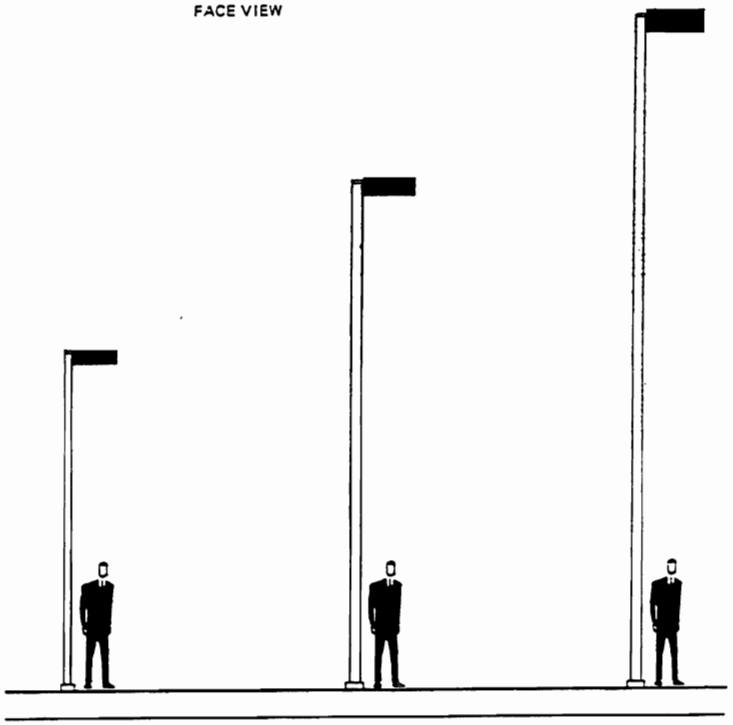
c. Incandescent

- Incandescent lamps are the least efficient light source (lumens/watt) and should not be used.

Fixture Example



EXAMPLE OF FIXTURE APPROPRIATE FOR USE IN PLATFORM, PARKING LOT, AND WALKWAY AREAS: CROUSE-HINDS ASL SERIES OR EQUAL. RIGHT: TYPICAL MOUNTING HEIGHTS FOR FIXTURE OF THIS TYPE. 20'-0" TO 30'-0" POLE LENGTH IS TYPICAL AT COMMUTER RAIL STATIONS.



SMALL UNIT RECOMMENDED MOUNTING HEIGHT 10' - 25'	MEDIUM UNIT RECOMMENDED MOUNTING HEIGHT 20' - 35'	LARGE UNIT RECOMMENDED MOUNTING HEIGHT 25' - 40'

C. WIRING

1. At all sites where regrading or resurfacing is planned, underground wiring shall be used. Underground wiring installed in Fiberglass Reinforced Epoxy (FRE) conduit sized in accordance with then Massachusetts Electrical Code (MEC) is preferred to overhead wiring for reasons of safety, reliability, lower long-term operating cost, and site appearance.

2. Wiring within canopies should be concealed whenever possible.

3. Any exposed wiring must be enclosed in conduit. The conduit should be installed in a manner consistent with the following criteria:

   - Follow architectural structural members, moldings, or ornamental details in as unobtrusive a manner as possible.
   - Match the color of the background on which it is mounted.
   - Resist vandalism with supports at intervals per the MEC within 9'-0" of ground level.

D. CONTROL COMPONENTS

1. Lighting control components at commuter rail stations include outdoor control centers and switches.

2. Outdoor control centers shall be provided at all stations. They shall be weatherproof and contain panelboards, lighting contactors, time clocks, and selector switches.

3. Recommended manufacturers of the control center enclosure are Hoffman Engineering Company, Lee Products Co., Russell L. Stroll, the Harry Richmond Company, or equal.

4. Control equipment utilized in commuter rail station lighting systems include:

   a. Selector Switches

      Selector switches provide control operation in three positions: Hands-Off- Automatic.

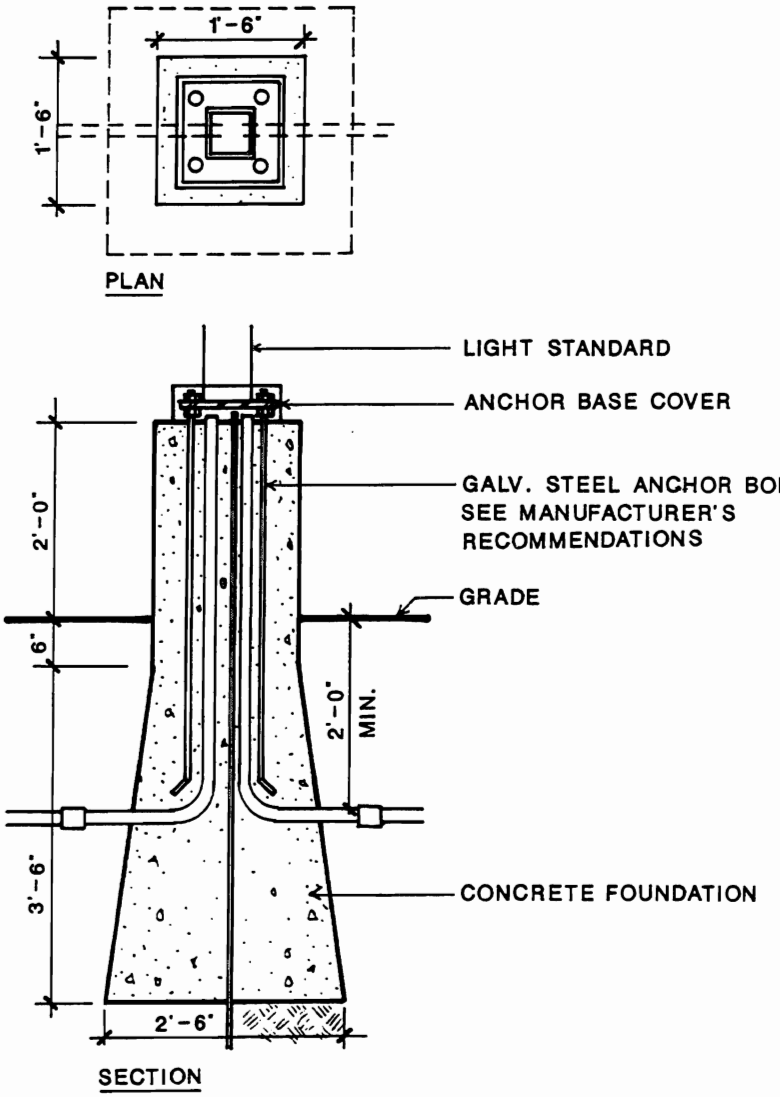
   b. Photoelectric Sensors

      Photoelectric sensors are fully automatic and provide illumination from dusk to dawn. Photoelectric switches are particularly applicable at locations where security and safety is a concern, such as shelters, station buildings, and track crossings.

c. Time Clocks

Time clocks shall be 24 hour and fully automatic and provide light at pre-set hours. Time clock components include such features as a seven day or astronomical dial, manual bypass lever, and sixteen-hour power reserve units. Time clocks are the most appropriate for parking area and platform lights that need not operate during the entire night. Time clocks shall be equipped with mechanically held contacts.

Typical Detail of a Pole Mounted Lighting Fixture Mounted on a 2'-0" High Concrete Pedestal for Protection from Vehicles



E. FIXTURE MOUNTING AND LOCATION

1. The following general fixture mounting criteria apply to commuter rail stations:

   - Minimum clearance between the bottom face of the luminaire and ground level is 9'-0"; the preferred minimum clearance is 11'-0".
   - Placement should be beyond the reach of persons standing on benches, trash receptacles, retaining walls, or other site furniture.

2. Criteria listed below apply to pole-mounted fixtures:

   - Fixture height: minimum of 9'-0" in pedestrian areas (platforms, walkways, etc.), 20'-0" minimum in vehicular areas such as parking lots and roadways; maximum of 30'-0".
   - Number of fixtures per pole : capable of receiving 1,2,3, or 4.
   - Location must be accessible for servicing by a bucket truck.
   - Poles shall be fixed, rather than hinged type base.
   - Do not use aluminum poles. Experience indicates that they break more readily than the steel pole.
   - Poles shall have handholes.
   - Fixture shall have individual cut-off optics.
   - Poles shall be mounted on a base extending a minimum of 2'-0" above finished grade at locations where poles are susceptible to damage by snowplows or other vehicles.
   - Shorter poles (20'-0" long) shall be able to resist damage from "whipping" and other acts of vandalism.

3. Typical pole-mounted fixtures which meet the above criteria include the Crouse Hinds ASL series, Sterner Lighting Systems (Model Type "Executive 25"), Gardco Lighting (Model Type "Form Ten EH"), or equal.

4. Fluorescent fixtures should meet the following criteria:

   - Be available in standard 4'-0" and 8'-0" lengths.
   - Provide single or double lamp capacity.
   - Have a 430 or 800 MA lamp capability.
   - Have a capability for use as a strip or individual fixture.

CHAPTER 4
GRAPHICS

I. INTRODUCTION

This section deals with the graphics requirements at commuter rail stations. As used in this manual, the term graphics refers to the full range of signs required to direct people to and within a commuter rail station site, warn of hazardous areas such as track crossings, and inform on matters of system use and operation. The format and appearance of the graphics described in this section are largely derived from the Authority's earlier graphics standards work; the MBTA Manual of Standards and Guidelines, Part V (1990 and subsequent revisions). These rapid transit system standards have been modified to meet the needs of more open and isolated commuter rail station environments.

II. DESIGN OBJECTIVES

User convenience, consistency, and durability are the principal design objectives of a commuter rail station graphics system.

A. USER CONVENIENCE

Graphics should be readily legible and should seek to minimize any uncertainty about train operation, present location, and destination.

B. CONSISTENCY

Graphics used at commuter rail stations should be consistent in appearance with those used on other lines operated by the Authority. This consistency contributes to the creation of a unified graphics system throughout the Authority.

C. DURABILITY

The various components of the graphics system- signs, sign frames, etc. should be fabricated from durable materials. They should be resistant to the effects of harsh weather conditions and vandalism and should require minimal long term maintenance.

III. DESIGN GUIDELINES

A. TERMINOLOGY

1. This subsection deals with the standard terminology that shall be used at all commuter rail stations, as well as guidelines for the use of non-standard terminology, punctuation, and abbreviations.

2. Authority Name

   In general, the full Authority name, Massachusetts Bay Transportation Authority, is not used at commuter rail stations. When used, however, it shall conform to formats presented later in this section.

3. Authority Symbol

The Authority's "T" symbol shall be used at all commuter rail stations to identify all entrances to the station site. At stations outside the Authority district, the "T" symbol shall be used in conjunction with the standard Trailblazer sign consisting of the "T", the words "Commuter Rail Station", and the standard directional arrow. The "T" shall also be located on the commuter rail system map panel and printed maps and schedules.

4. Platform Information

a. All stations with double or multiple track operations shall have the following destination information on the information band of the station identification signs:

Inbound: "Inbound to Boston"
Outbound: "Outbound"

b. All stations with single track operations shall have the following destination information on station identification signs:

Two lines using 1-1/2" text in the white band with a special arrow and text "Direction to Boston" and below it "Direction to xxxx" (outer terminal).

c. Exceptions to the preceding guidelines are North Station and South Station where the terms "Inbound to Boston" and "Outbound" are deleted.

d. Space permitting, additional local destination information may be placed in the information band of the station identification sign. Terminology should conform to the grammatical, punctuation, and abbreviation guidelines discussed below.

e. At multi-track stations (island platform or 2 side platforms) provide track number/destination signs above the platform, at right angles to the track.

5. Other Standard Terminology

a. At stations where "live" parking, or a drop-off/pick-up area is provided, information directing the user to that area shall include the following terminology:

"Drop Off/Pick Up" and the international symbol of accessibility.

b. A warning sign with the phrase "Look Before Crossing" shall be located in front of all vehicular and pedestrian track crossings.

c. A warning sign with the phrase " Danger Will Not Clear Man on Side of Car" shall be located at each end of high level platforms.

6. Grammatical Guidelines

a. Terminology should be consistent in style and format with that used by the Authority outside the commuter rail system. Messages should be brief, avoiding unnecessary words and punctuation. Some examples follow.

- "To" is normally not used with an arrow-circle unit, as in "To Exit", "To Platform", and "To Town Center". Exceptions to this rule are phrases such as "Exit to Mass. Ave." and "To Trains", which are used with the arrow-circle unit.
- Avoid phrases such as "Left to Town Center". Use the arrow-circle unit in combination with the words "Town Center".

7. Punctuation Guidelines

a. Minimize use of punctuation to be consistent with good grammatical form and clarity of meaning.

b. Use the comma between items in a series and to separate two pieces of information. Example: "Town Center, Norwood Hospital".

c. The period is used after an abbreviation and for the abbreviated versions of morning and evening. Example: "a.m.", and "p.m.".

d. The hyphen is used to denote all joint names. Example: "Central Square-Lynn". While the hyphen is normally used between the words "Drop Off/Pick Up" sign presented later in this section.

e. The ampersand is used in place of the word "and" when connecting two words which naturally belong together because of similarity of function or geographical proximity. Example: "Hamilton & Wenham".

In the case of unusual space constraints the ampersand may be substituted for the word "and".

8. Abbreviation Guidelines

a. Limit use of abbreviations to the most common and widely understood. Among those that may be used are:

"St."	street
"Ave."	avenue
"Pl."	place
"Blvd."	boulevard
"Pkwy."	parkway
"Rte."	route
"N."	north
"S."	south
"E."	east
"W."	west
"Ctr."	center
"Sq."	square

B. PICTOGRAPHS

1. Pictographs are graphic symbols that are used to convey a message in a more direct and readily recognizable manner than word signage. In the case of warning or prohibition signs (such as "No Smoking and "No Parking") the pictograph is often a more empathetic method of conveying the message than the words alone. Pictographs identifying accessible elements are to be accompanied by verbal description placed directly below the pictograph.

2. The standard pictographs to be used at commuter rail stations are based on the recommendations for a uniform pictographic vocabulary proposed by the American Institute of Graphic Arts to the U.S. Department of Transportation. The pictographs are described in more detail in the publication, Symbol Signs, DOTOS-40192, which may be ordered from: the National Technical Information Service, Springfield, VA 22151.

C. CARTOGRAPHY

1. The cartographic or map requirements at commuter rail stations are quite limited by comparison with those of rapid transit stations. Commuter rail station environments are generally quite open, thereby reducing the need for directions around the station and to destinations away from the stations. Two types of maps are potentially appropriate at commuter rail stations: the system map and the rapid transit line map.

2. System Map

The commuter rail system map is a diagrammatic representation of the entire commuter rail system that is consistent in format with the Authority's diagrammatic map of the rapid transit system. This map typically has three colors (purple, black, and white) and identifies connections with the Authority's rapid transit system. The purpose of

this map is to provide users with general knowledge of the commuter rail service available and the system's connections to other Authority services.

3. Rapid Transit Line Map

This map is provided at stations where there is a direct or nearby connection to the rapid transit system.

D. SIGN TYPES

1. Four types of signs are generally found at commuter rail stations: identification, directional, regulatory/warning, and system use. A large share of the signs are in the identification and directional categories. A general description of each sign type, as well as location guidelines, is presented below. Sign layouts and methods of construction are described in Design Criteria.

2. Identification Signs

a. The two most common signs in this category are the System Identification Sign and the Station Identification Sign.

b. System Identification Sign

- Purpose: to identify the location of stations on the Authority's system.
- Description: consists of the Authority's "T" symbol mounted in a circular metal frame on a free-standing pole. It is similar in design to the "T" lollipop -shaped sign used at rapid transit stations, except the commuter rail version is not back-lighted. Illumination of this sign should be from adjacent, pole-mounted fixtures.
- Location: at all major vehicular and pedestrian entrances to the station. Experience indicates that two system identification signs per station are normally sufficient.

c. Station Identification Sign

- Purpose: to assist those disembarking from the train in identifying the station. Also to identify the platform necessary to direct passengers to local destinations.
- Description: consists of a 9" high station name band and a 6" high information band typically mounted in a freestanding frame. The information band identifies the platform ("Inbound to Boston" or "Outbound"), and in some instances contains local destination information.
- Location: along the back face of the platform parallel to the track(s). Preferred spacing of the signs is at 85'-0" intervals on each platform (one coach length). The minimum number of station identification signs at a station shall

be one per platform. The signs should also be located adjacent to a platform light fixture for maximum visibility during evening hours. Avoid locating these signs directly across the tracks from a seating area to discourage vandals from sitting on the benches and throwing objects at the signs.

d. Track Number /Destination Sign

- Purpose: to identify the destination of the train located on the designated track.
- Description: The track number and destination may be used in combination with the commuter rail combination sign panel. Refer to the MBTA Manual of Standards and Guidelines, Chapter 5 for more information.

e. On-Site Identification Signs

- A variety of on-site identification signs will typically be required in limited numbers. Among these are signs identifying accessible parking spaces, bus and drop-off zones, compact car spaces, space numbering and signage and taxi stands. With the exception of the required accessible parking signs, the number of these signs should be kept to an absolute minimum.

- The locations of these signs are site specific. Signs identifying accessible parking spaces should be provided for each designated parking stall. These signs are normally pole-mounted, and care should be taken in locating the poles a minimum distance of 1'-0" from the outside face of a curb in areas where vehicles may be parked parallel to the curb; in areas of perpendicular parking, the minimum distance is 2'-6". "Compact Car Only" sign should be located at either end of the row of parking spaces with arrows pointing towards the center of the row. "Compact Car Only" signs without arrows should be located every 100 feet between these two signs.

3. Directional Signs

a. Included in this category of signs are off-site trailblazers, as well as signs providing directions around the station site. Directional signage should include signage to identify accessible routes between access platforms and parking areas and/or entrances and exits. Where the accessible route diverges from that used by the general public, an access symbol with directional arrow is required.

b. Trailblazers

- Purpose: to direct potential users of the commuter rail system to stations and to improve access for drop-off/pick-up vehicle drivers who are unsure of the station location.
- Description: consists of the "T" symbol, the words "Commuter Rail Station", and the Authority's standard directional arrow. It is pole-mounted.
- Location: typically along several major corridors to a station. Usually, all signs are within a several mile radius of the station and are placed at all key decision points. At stations outside the Authority district boundary, trailblazers are also mounted on the system identification sign at the station entrance since the "T" symbol alone may not be recognized in these areas.

c. On-Site Directional Signs

- In addition to the directions that may be provided on the station identification signs, directional signs may also be required to direct motorists to drop-off/pick-up areas, bus drop-off/pick-up zones, remote accessible parking areas, the direction of major highway routes from the parking lot exit drive and the accessible route to the platform entrance, if it diverges from the general route to the platform entrance. Use of these signs should normally be limited to the larger, more complicated sites.
- These signs combine the standard pictographs with the directional arrow.
- Locations of the signs will vary with site conditions. Minimum curb clearances discussed earlier in this subsection should also be maintained with these signs.

4. Regulatory/Warning Signs

a. Three types of signs in this category are generally used at commuter rail stations-"Look Before Crossing", "No Smoking", and "No Parking".

b. "Look Before Crossing" Sign

- Purpose: to alert motorists and pedestrians of any on-site railroad track crossing.
- Description: a pole-mounted sign containing the phrase, "Look Before Crossing".
- Location: at all vehicular and pedestrian approaches to a track crossing, including all main line tracks as well as freight sidings. Signs should be located a minimum of 8'-6" from the centerline of a single track; in double or multiple track locations, signs may be placed between

tracks if a minimum clearance of 6'-9" to both track centerlines is maintained.

c. "No Parking "Signs

- Purpose: to identify areas on the station property where parking is not allowed.
- Description: consists of the standard pictograph mounted on a pole.
- Location: based on the needs of each station, but due to potential vandalism, the number of signs should be minimized. The 1'-0" and 2'-6" curb clearance criteria discussed previously in this subsection also apply to this sign.

d. "No Smoking" Sign

- Purpose: to inform users of the Commonwealth of Massachusetts law prohibiting smoking in Authority stations and vehicles.
- Description: a standard combination pictograph/written message sign provided by the Authority.
- Location: sign must be displayed in all enclosed waiting areas.

5. System Use Signs

a. Current Authority policy is to provide two types of system use information at commuter rail stations. One is a diagrammatic map of the system, and the other is train schedule information.

b. System Map Panel

- Purpose: to inform commuters of all stations/locations served by the commuter rail system, as well as stations at which connections can be made to other service provided by the Authority.
- Description: a diagrammatic line map similar in format and design to the Authority "spider map" of the rapid transit system. It is typically presented on a 4'x 4' metal panel that is mounted on the station identification sign frame.
- Location: integrated into a station identification sign frame that is located at a central point on the inbound platform. Every station should have at least one system map, and some stations with higher ridership may warrant two maps, depending on the station layout. At least one system map panel must be located on the accessible route.

c. Schedule Panel

- Purpose: to provide commuters routine information such as train schedules, notice of changes in service, fares, etc.
- Description: this type of information is subject to relatively frequent change. The approach used by the MBTA is to provide a combination sign panel that provides visual and tactile station identification, route maps, and schedules.
- Location: Provide at least one route map/schedule case combination along the accessible path to the platform. Refer to Part V, Graphics chapter of the MBTA Manual of Standards and Guidelines for more information.

IV. DESIGN CRITERIA AND DETAILS

A. GENERAL

1. The typography, symbols, arrows, pictographs, colors, and sign layouts described below are standards to be applied in the design of all signs for commuter rail stations. These standards are based on the Authority's Manual of Standards and Guidelines, Part V, Graphics.

2. The sign materials and methods of construction presented below are not standards, but are the product of the cumulative experience of the Authority with many previous sign design and fabrication contracts for both rapid transit and commuter rail stations.

B. TYPOGRAPHY

1. The standard Authority font is Helvetica and is illustrated on graphic pages following in this chapter. It is highly legible and available in all media: metal composition, photo-composition, wax transfer lettering, and vinyl adhesive-backed pre-cut letters. The standard weight used by the Authority is medium, and only capital letters shall be used on signs described in this manual.

2. Letter Size for Station Platform and Related Directional Signs:

   a. Four letter sizes most generally used on the signs described in this manual - 6", 4", 3" and 1-1/2".

   b. 6" letters are used on station identification signs for:
      - Station name in the 9" color band.

   c. 4" letters are used for:
      - Station name in the 6" color band.

   d. 3" letters are used for:
      - All information in the 6" white band except as noted below.

   e. 1-1/2" letters are used for:
      - Information in the 6" wide band where space is limited.

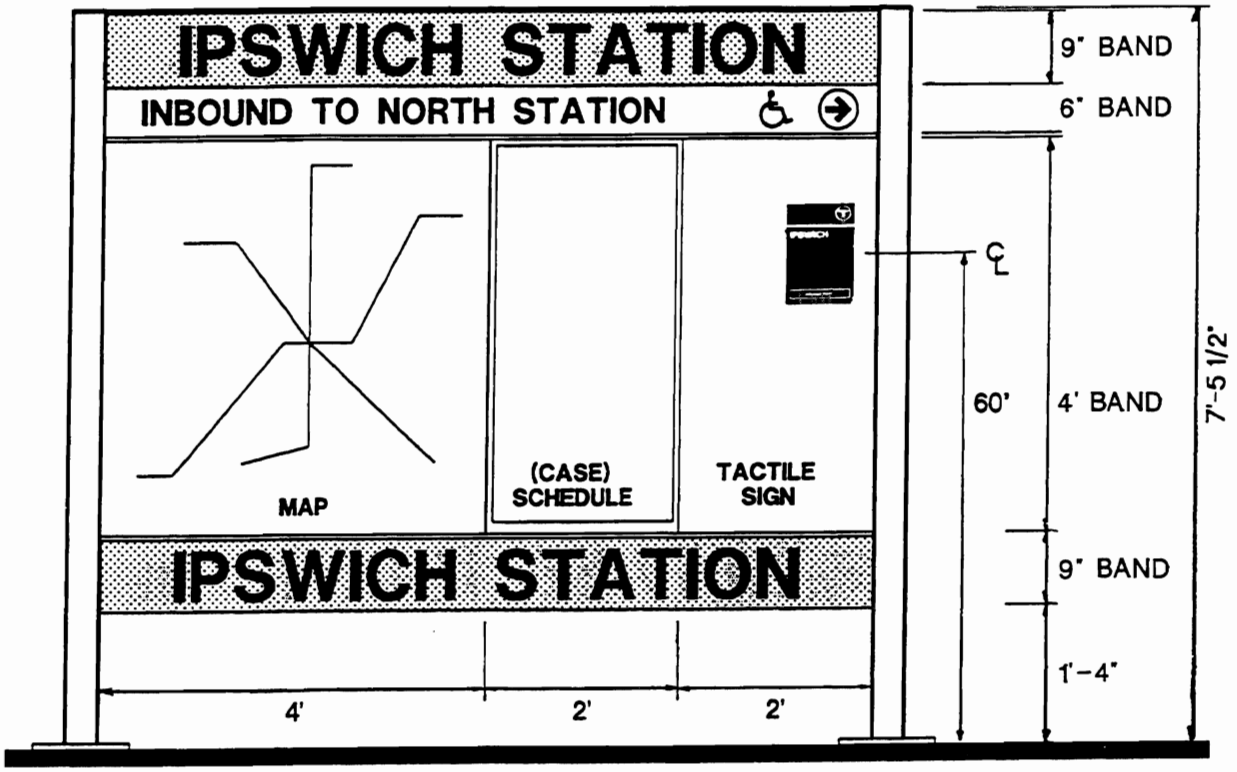
3. Letter size for site signing:

   Size varies to suit available space and intended use. See sketches of typical standard signs.

4. Letter and Word Spacing

   Letter and word spacing shall be in accordance with the rules established in Part V of the Authority's Manual of Standards and Guidelines and reproduced on the following pages. However, exceptions to this spacing are permitted in the case of space limitations. All exceptions must be approved by the Authority's Design Development Department.

Commuter Rail Combination Sign Panel



Commuter rail combination sign panels provide required information for visual and tactile station identification, route maps and schedules. Sign bands may also contain information concerning track number, accessible route, etc. Provide at least one route map/schedule case combination along the accessible path to the platform. Where a raised access platform is located at a remote location from the main platform, provide this sign combination in both areas. Provide Tactile/Braille ID. sign in at least one central location along each platform.

Source: MBTA Manual of Standards and Guidelines, Chapter V.

C. ACCESSIBLE FEATURES

1. General Requirements

Please refer to the Graphics chapter of the MBTA Manual of Standards and Guidelines, Part V, Section Q for detailed information about ADA regulations for MBTA signage.

a. Character Proportion: The standard Helvetica Medium typeface used in MBTA signage should be used to comply with ADA specified width-to-height ratios.

b. Character Height: Where signs are mounted suspended overhead, letter height must be a minimum of 3".

c. Finish and Contrast: Characters should provide the maximum contrast with their background. White characters against a black background are the most legible. ADA requires that the characters and background should be of a non-glare finish, such as matte or eggshell. It is also helpful to have contrast between the sign and the wall in which it is posted on, and post the signs as frequently as possible.

2. ADA Sign Types

a. Tactile/Braille signs: Required to identify permanent rooms, stations at entrances and platforms. The centerline of the sign must be 5'-0" A.F.F.

b. Station Identification Signs: Consist of the typical MBTA sign bands system. ADA imposes certain requirements as to their location and frequency.

c. Directional Signs: Provide information that riders need to use the system. Additional signs are required when 1) the accessible route diverges from the path of travel for the general public, or 2) when not all of a particular element are accessible.

d. Variable Message Signs: If a public address system is used, ADA requires that a visual message system be provided for hearing impaired persons.

e. Miscellaneous Signs: Other signs such as clocks, and accessible parking signs are regulated by ADA guidelines. Please refer to the Graphics chapter of the MBTA Manual of Standards and Guidelines, Revision 1995 for more detailed information.

D. SYMBOL, ARROW, AND PICTOGRAPHS

1. Authority "T" Symbol

The "T" symbol is typically 3'-3" in diameter when used on the system identification sign.

2. Directional Arrow-Circle

   a. While its size will vary, the Authority's standard arrow-circle unit should conform to the following criteria:

      - The circle and arrow should always be used together and in the proportions established by the art work in the accompanying illustration.
      - The height ratio of the arrow-circle unit to accompanying letters and numerals is 5:4, as illustrated on following pages.
      - The arrow-circle unit may be used in any of the orientations presented on the following pages.

   b. Train Direction Arrow

      This arrow is detailed on the following pages. It is to be used preceding and following train direction information at stations with single track and island platforms.

3. Pictographs

   a. The pictographs described earlier are provided by the Authority for a fee to be determined.

   b. Pictographs should be sized to satisfy specific legibility requirements. Two commonly used pictographs - the parking for the handicapped and no parking signs - are illustrated with typical dimensions on following pages.

E. USE OF COLOR

1. Criteria presented below concerning the use of color on commuter rail signs are based on the guidelines established in Part V of the Authority's Manual of Guidelines and Standards.

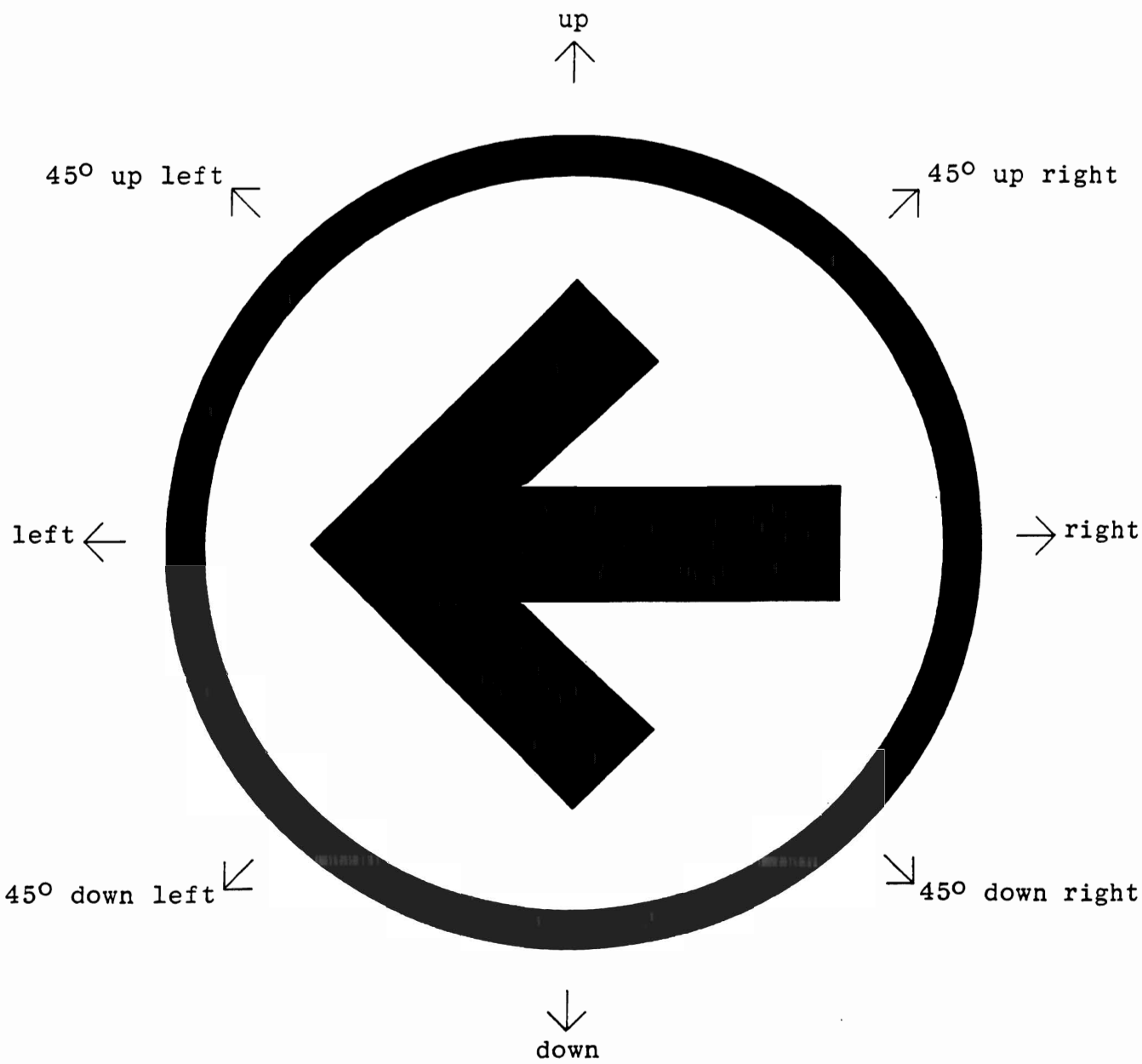
2. A maximum of five colors will normally be used for commuter rail station signs: black, white, purple, red, or yellow.

3. Black letters, symbols, and arrows on a white field (back-ground) are used to convey most directional and station identification information at a station. This standard is consistent with previous Authority standards and is also the most economical. Following are exceptions to the standard.

4. Purple

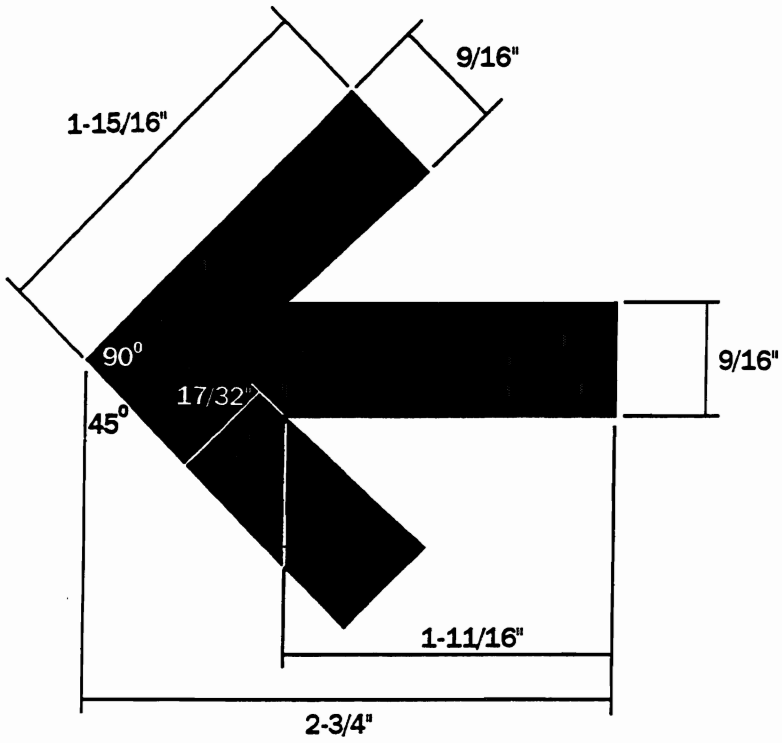
   a. The standard color for commuter rail in the Authority's color-coding system is purple. Its application to commuter rail signs is similar in concept to the use of color on the rapid transit system signs. The purple color is used on the 9" high station name band and to identify commuter rail lines on the system map. In addition the color is used on the trailblazer signs as a field for the "T" s symbol and the words "Commuter Rail Station".

Arrow/Circle

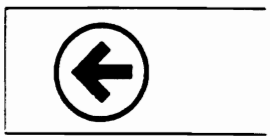


Train Direction Arrow

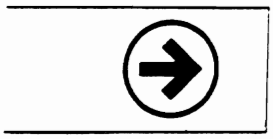
This arrow is to be used without a circle for indicating the direction of Inbound and Outbound trains for island platforms and single track stations.



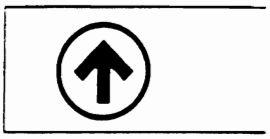
Arrow/Circle- Directional Conventions



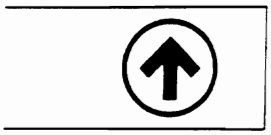
Go left



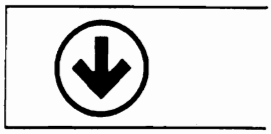
Go right



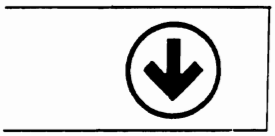
Go straight



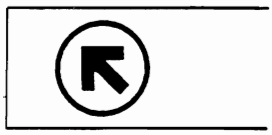
Go straight



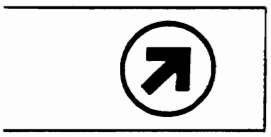
Go down
You have arrived



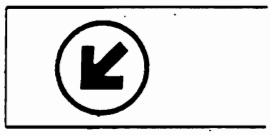
Go down
You have arrived



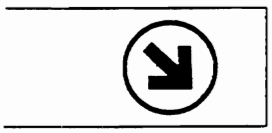
Up left,
or half-left



Up right,
or half-right



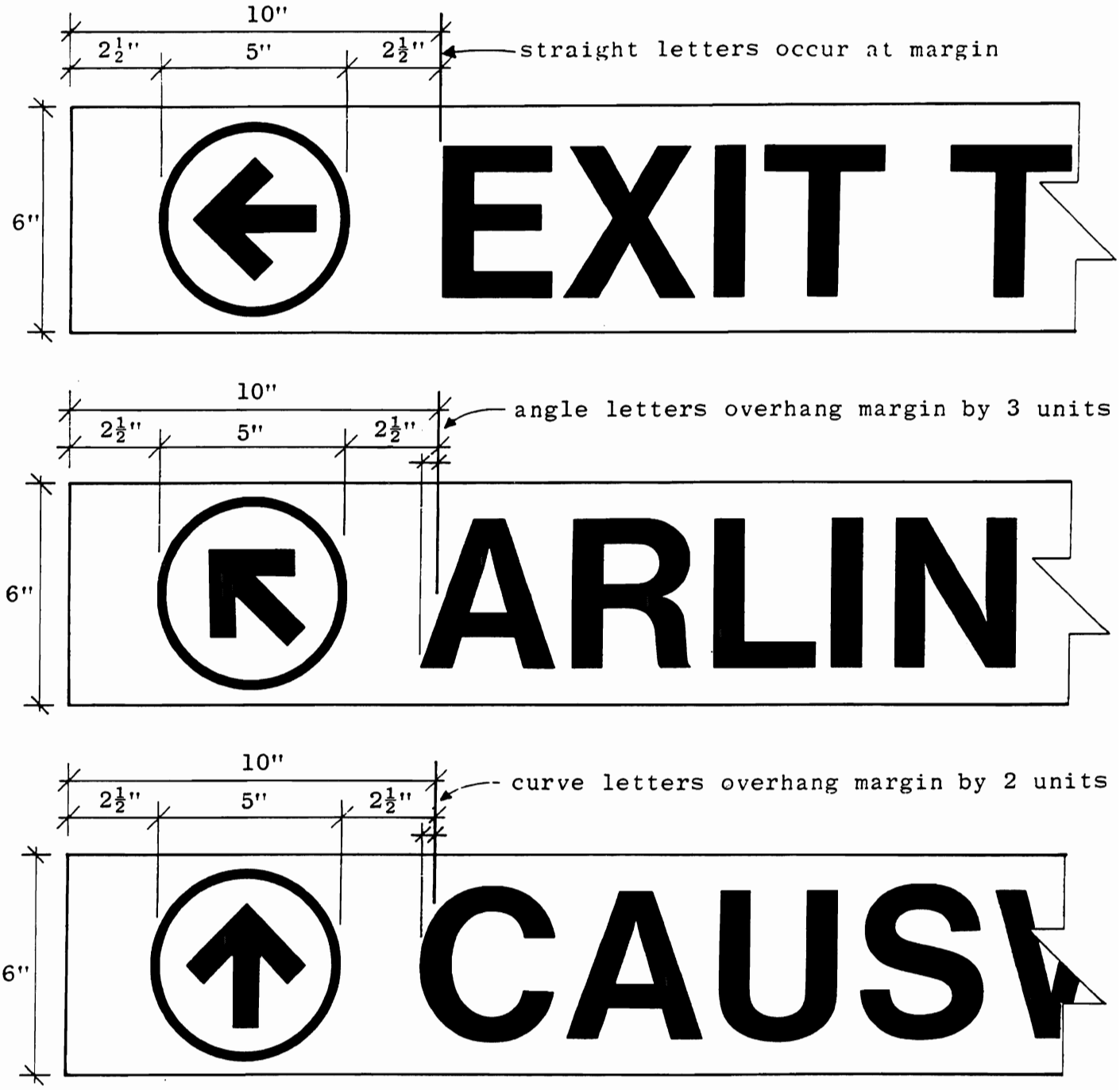
Down left only



Down right only

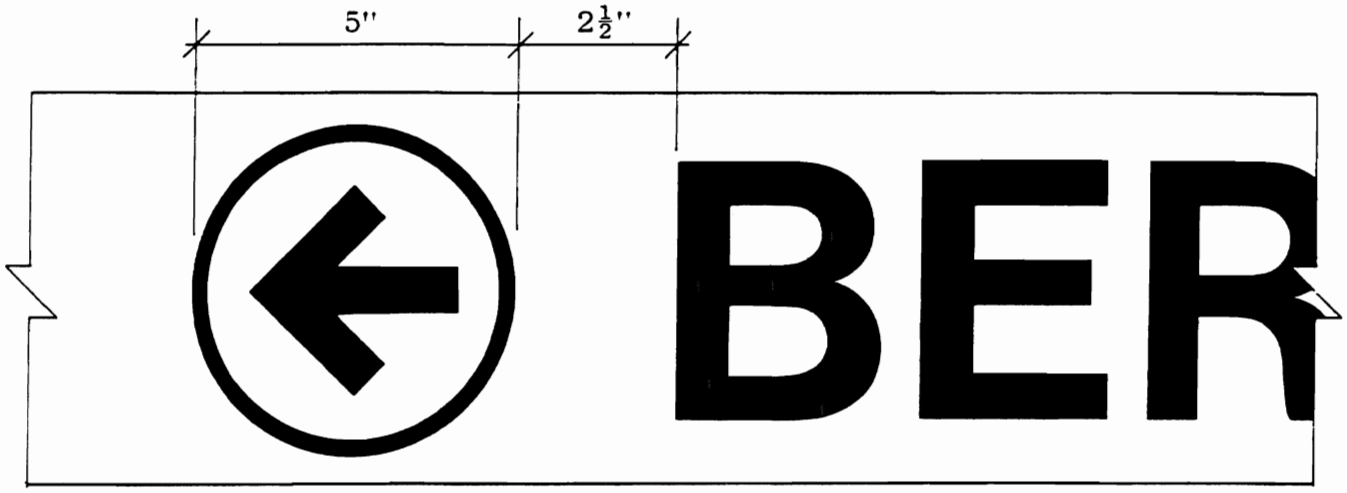
These are the proper attitude positions for the Arrow/Circle decal. Use the Arrow/Circle either left or right. Do not use on both sides of a sign unless one end or the other is obscured by a column, wall, etc. from some viewing positions. See following page for relationships to the edge of the sign and Section D of this chapter for use.

Use of Arrow /Circle- Opaque Sign Bands

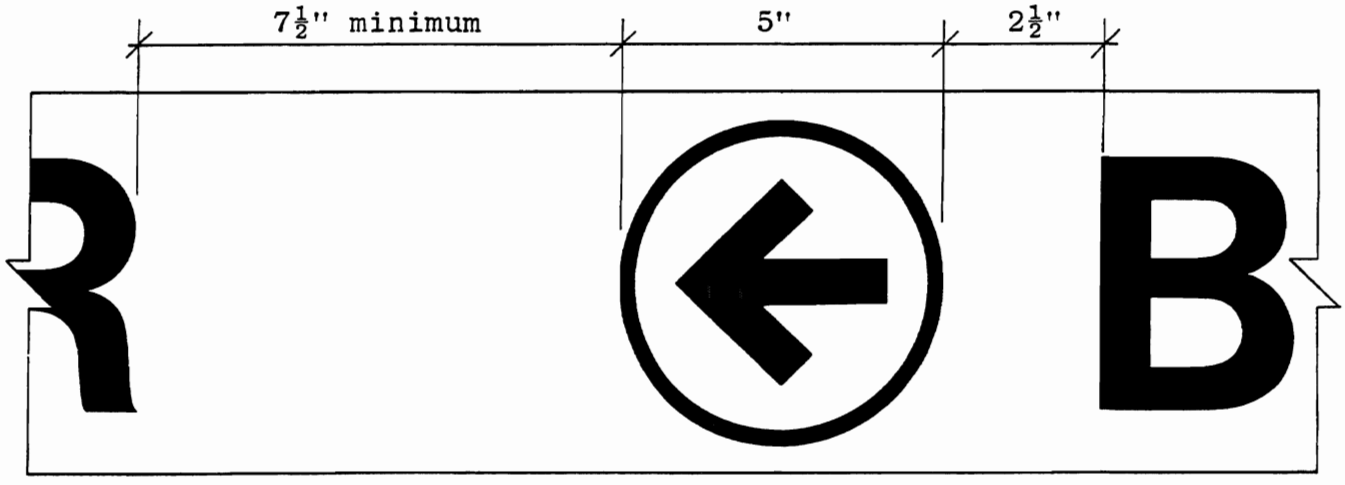


On a 6" signband, letters are 3" high and the arrow/Circle diameter is 5". The outside edge of the Arrow/Circle is 2 1/2" from left edge of signband and 2 1/2" from lettering margin. Spacing remains the same with the Arrow/Circle and lettering on the right side of signs.

Use of Arrow /Circle- Continuous Opaque Sign Band

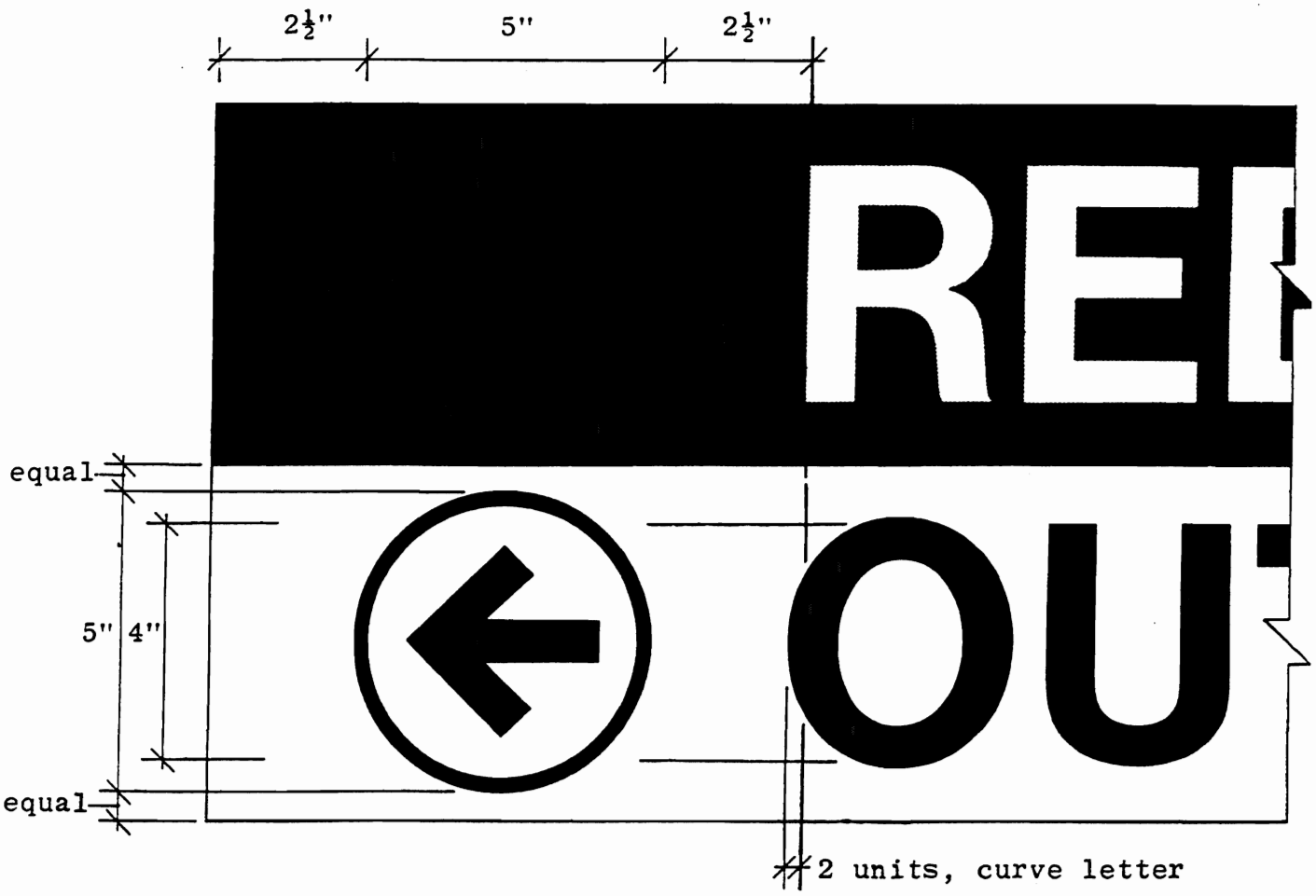


Single floating directional sign



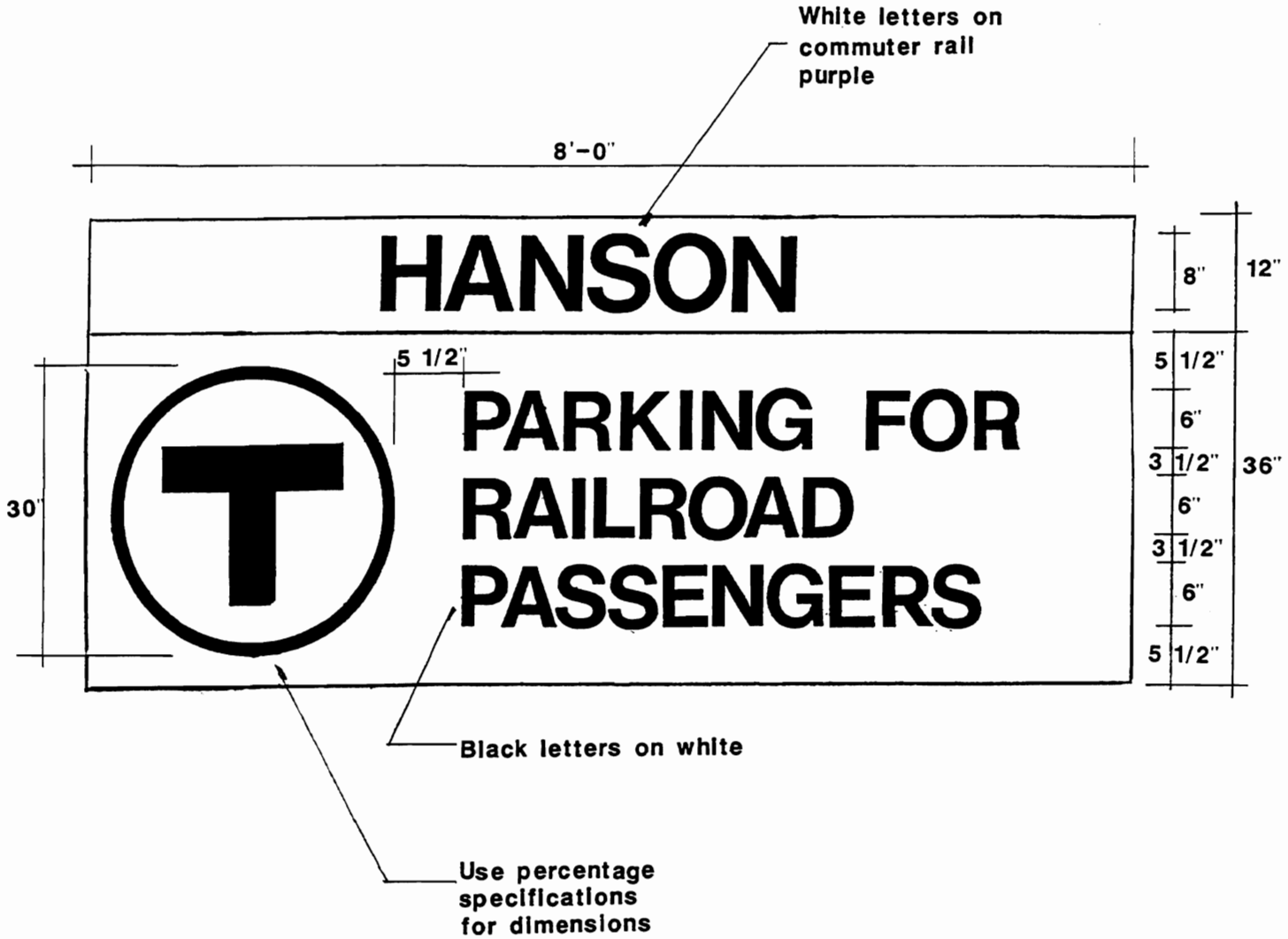
Two adjacent directional signs

Use of Arrow /Circle- Line/Direction Signs



On signbands that provide information together, as a pair, the arrow must appear once, on the white band.

Sign for Designated Parking for Railroad Passengers



b. Commuter rail purple is specified using the Pantone Matching System (PMS) of offset printing inks developed by Pantone, Inc. Pantone Color Selector is available through art supply stores. The color number for commuter rail purple is PMS 241 (uncoated) and PMS 249 (coated). While experience indicates that this color may be difficult to match in certain applications, the designer should attempt to achieve the closest possible match in all uses of purple on the commuter rail system. See the accompanying chart for the Authority's standard color specification for purple in brush and spray paints.

5. Red

a. The color red is used on regulatory/warning signs, especially the "No Parking" and "No Smoking" signs.

b. Red should be as specified in the accompanying chart.

6. Yellow

a. The color yellow is used on the vehicular/pedestrian track crossing warning sign, "Look Before Crossing".

b. Yellow should be as specified in the complying chart.

7. Blue

a. The color blue is used for accessibility. The blue used for accessible parking space signs should match Pantone 300 (coated) and Pantone 293 (uncoated).

STANDARD COLORS

Pantone (printing ink) Color	Uncoated	Coated	Dupont (paints) Imron (spray)	Dulux (brush)
Red	485	485	58209UM	93-58209H
Blue	293	300	77257U	93-77257
Orange	144	152	60659UH	93-60659
Green	348	348	5316UH	93-5316
Purple	241	249	1976UM	
Yellow	123	123	6808U	93-6808
Silver	877	429	44400UH	
Dark Gray	a431	431	55322U	93-55322
Light Gray	422	422	55137U	93-55322
White			817U	93-21667
Beige	454	454	4480U	93-221667
Aqua	340	569	72218U	93-72218
Black	Black	Black	99U	93-005

F. SIGN LAYOUT

1. Sign Layout criteria generally are based on standards prescribed in the Authority's Manual of Guidelines and Standards, Part V. They are discussed below in terms of the four categories of signs.

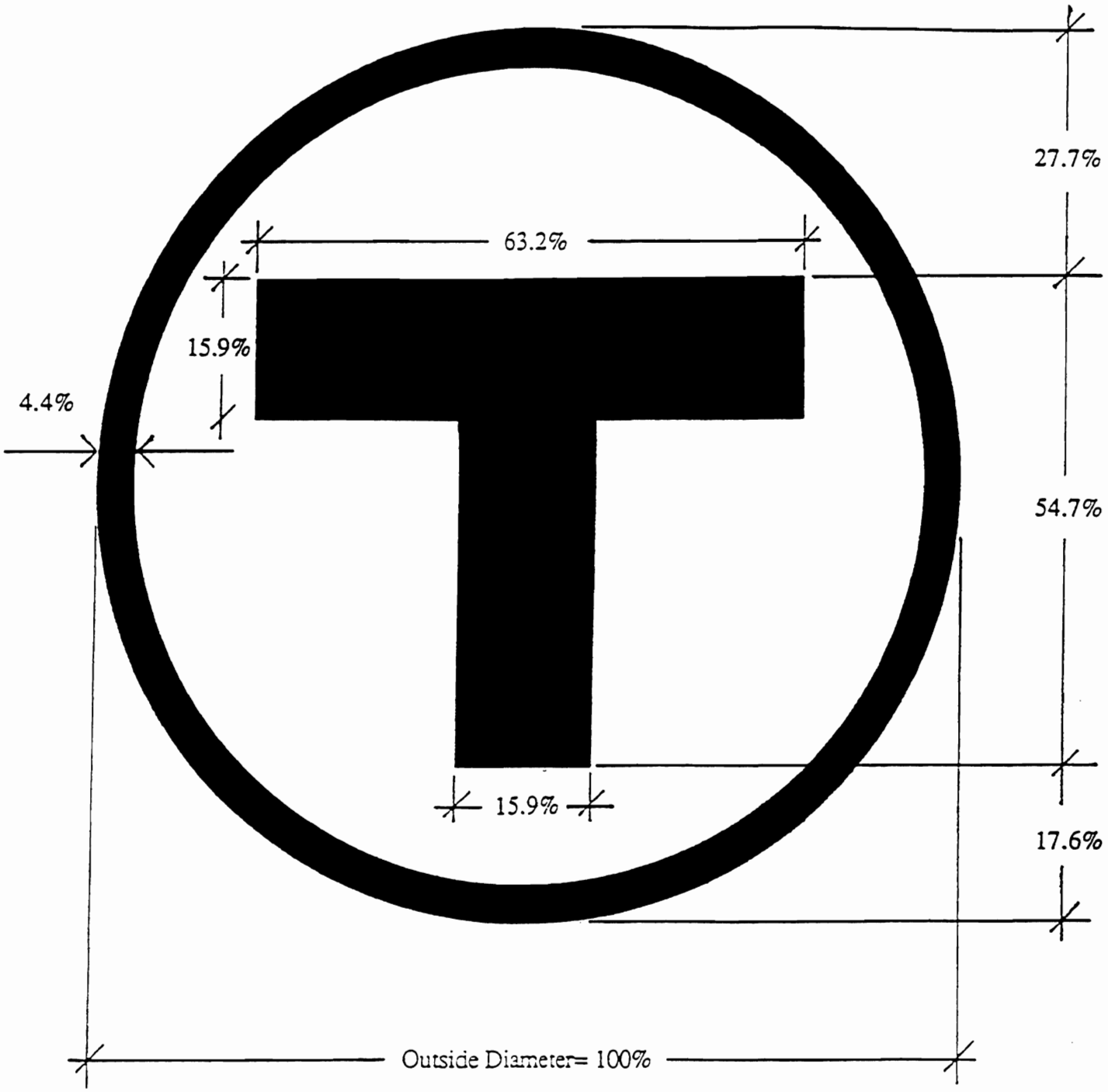
2. Identification Signs

   a. The system identification sign, the "T" symbol, is laid out in accordance with the accompanying symbol art work except that the circle surrounding the "T" is omitted. This circle is replaced by the circular metal frame surrounding the "T".

   b. Station Identification Sign

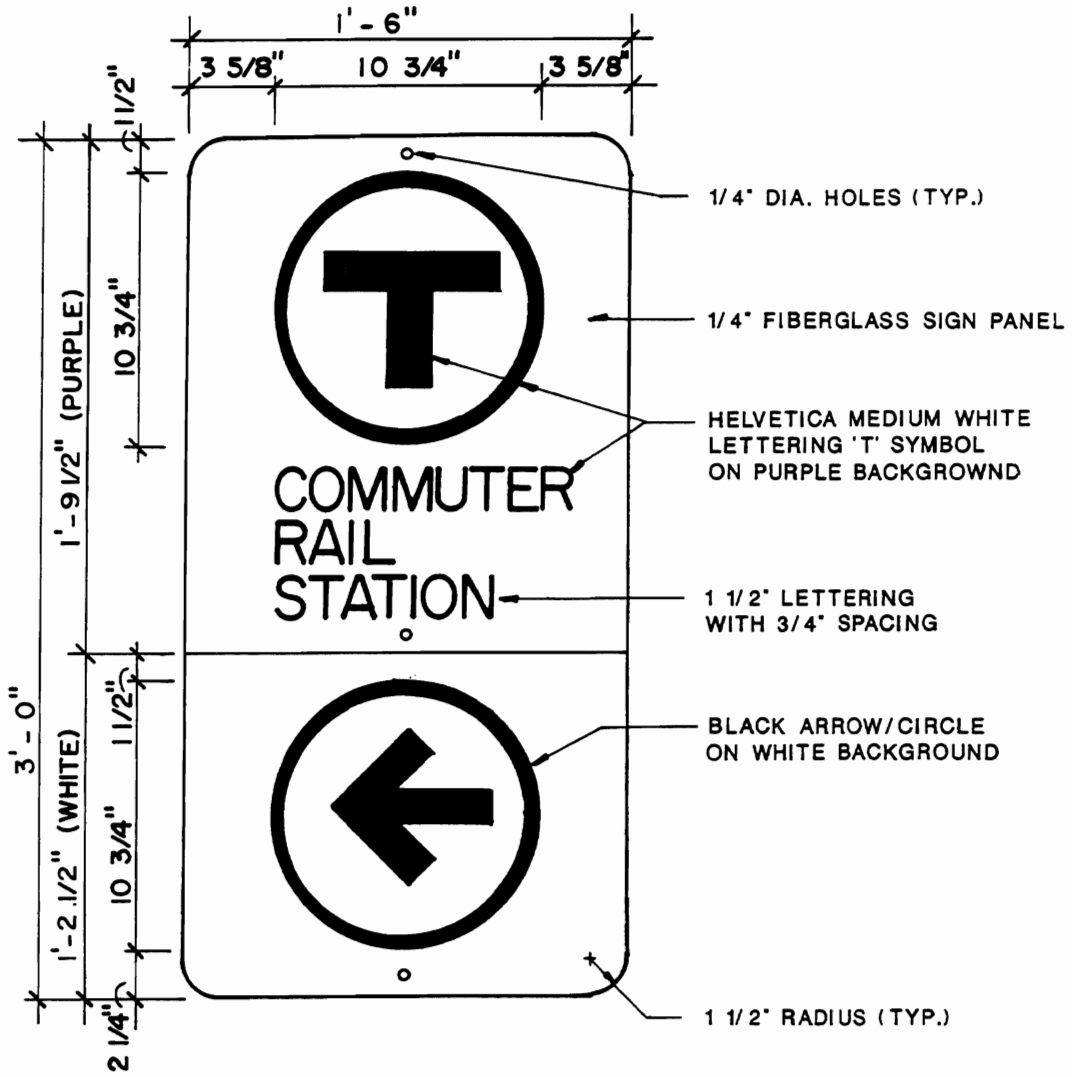
      - The station name is on the purple colored band, which is typically 9"x 8'-0". The height of the letters (6") may be reduced if necessary to fit the station name within the 8'-0" panel.
      - The platform identification "Inbound to Boston" and "Outbound To (Terminal Station or Stations)" is centered on the white portion of the band (6"x 8'-0") with 3" text in double or multiple platform conditions. See the accompanying illustrations for examples of this layout.
      - For single track and island platform conditions, the 6" information band contains "Direction to Boston" in 1-1/2" text over the text "Direction To (name of terminal station or stations)" in 1-1/2" text. Both lines of directional text are either preceded or followed by a special train direction arrow detailed in the preceding pages. The information is left or right-justified in accordance with the following illustration.
      - The margins between the arrow-circle unit, the borders of the panel, and adjacent words are standards to be maintained with other information presented on the panel.
      - Local destination information may be incorporated into the 6" information panel along with the platform identification. Where space is limited, 2 lines of 1-1/2" text may be used.
      - Messages (platform identification and local destinations) must be separated.
      - Letter size must be the same for each message.
      - Letter size may be reduced below the standard 4" height when additional space is required. The circle-arrow unit must also be reduced in size proportionally to maintain the same 5:4 ratio of outside circle diameter to letter height.
      - Provide an arrow-circle unit for messages in a single platform condition.

Symbol, Diameter Larger Than 4"

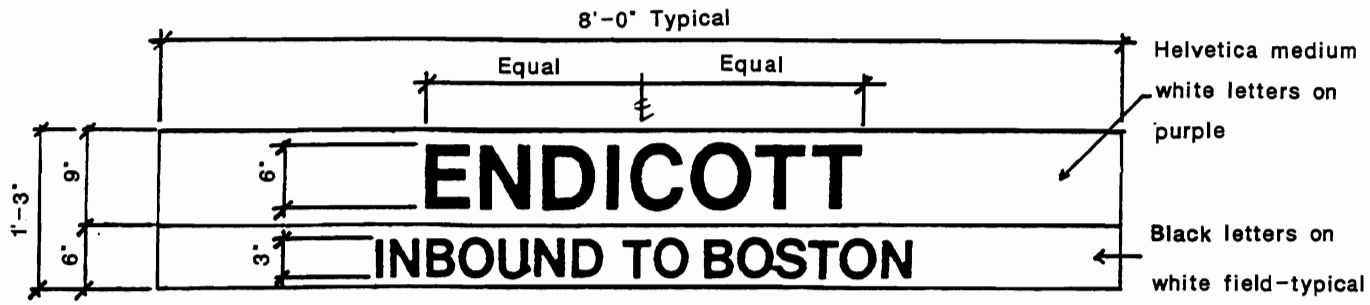


• **Logo Proportions**
example: for 20" diameter; 20 x 54.7% = 10.94" high T

Standard Trailblazer Sign

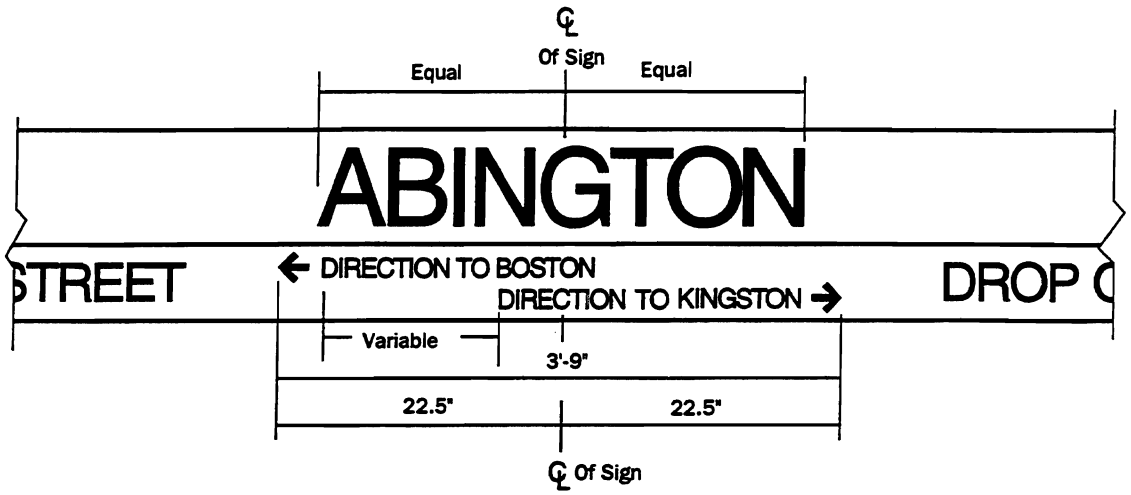


Destination Information, Double or Multiple Track Station with Side Platforms.
(Assume right hand direction of trains)

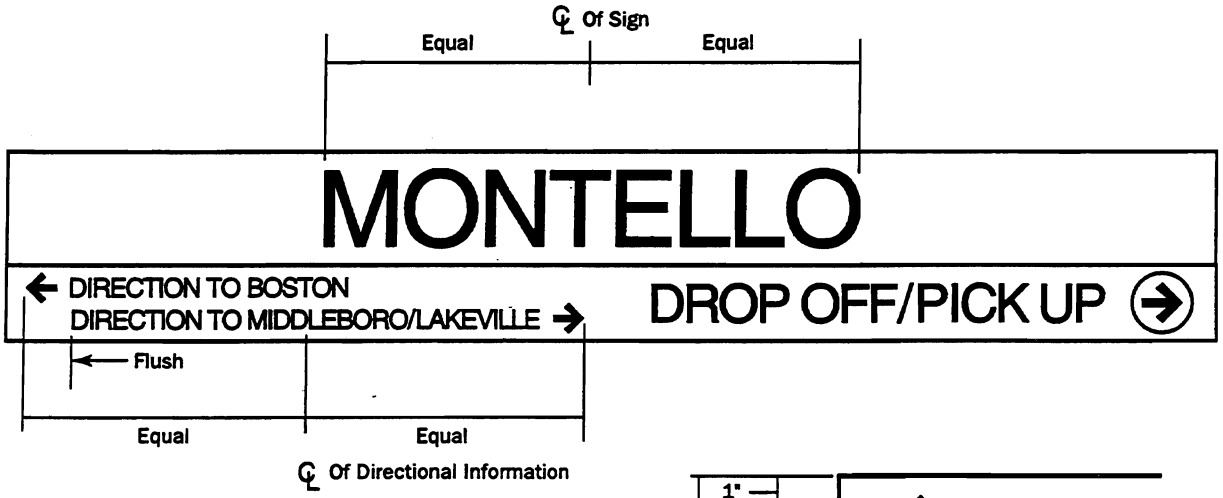


Island Platform and Single Track Destination Information

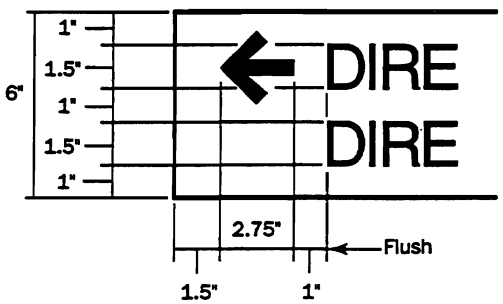
These designs should be used for island platforms with multiple tracks or for single track stations where trains heading inbound and outbound make use of the same track.



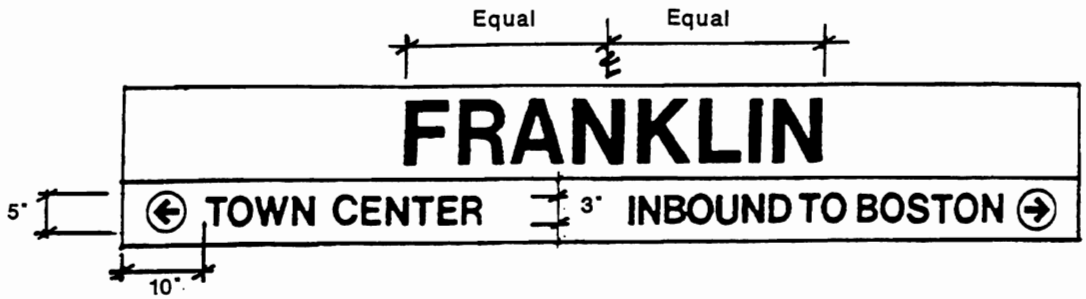
12 Ft. Station Identification Sign



8 Ft. Station Identification Sign



Example of Standard Method for Inserting Local Destination Information on Station Identification Sign



c. Other Identification Signs

The other most commonly used identification sign is the pictograph used to identify parking spaces for the handicapped. The standardization of pictograph sign sizes is not appropriate, but a convenient size used in the past consists of a maximum image area dimension of 10 3/4" on a 1'-2"x 1'-2" sheet metal field (see accompanying illustration).

3. Directional Signs

a. The trailblazer sign is a commonly available size of sheet aluminum: 1'-6"x 3'-0" and is Authority standard in terms of letter and symbol size, color, and layout. The standard sign is described in the accompanying illustration.

b. Other directional signs, such as those directing the motorist to drop-off/pick- up areas and additional parking, will vary in size with site conditions. The relationship of the arrow-circle unit to the message unit (e.g., the "P" symbol or "Drop Off/Pick Up") should be in accordance with the examples presented in the accompanying illustration.

c. All copy on directional signs located away from the platform should be left-justified.

4. Regulatory/Warning Signs

a. The "No Parking" pictograph sign should be designed in accordance with the pictograph layout criteria presented above.

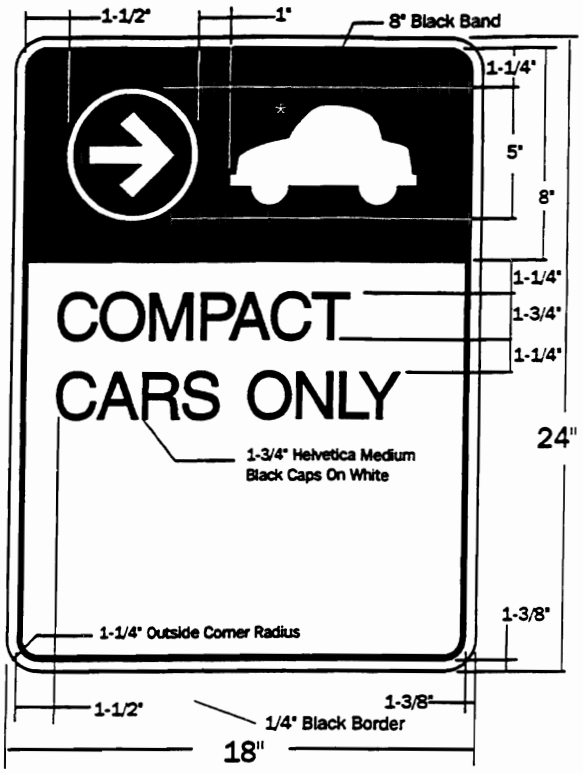
b. The vehicular/pedestrian track crossing sign must conform to the standard illustration on the following page. For this sign only, the words are stacked and centered rather than left-justified.

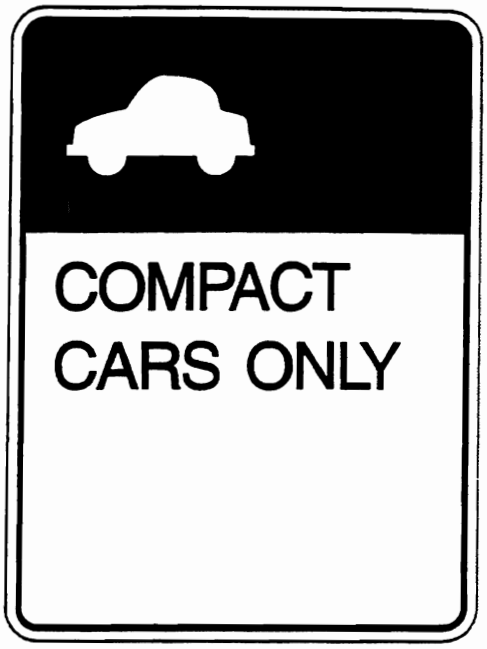
5. System Use

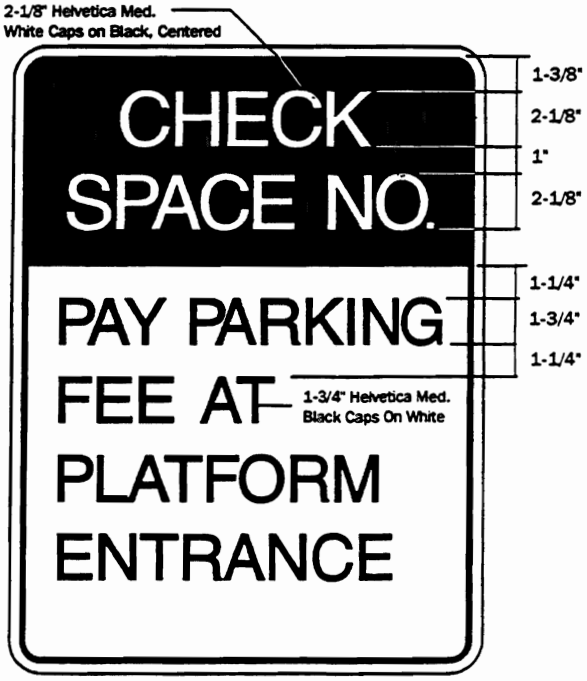
a. The system map is a standard size. Camera ready art work for these maps is provided by the Authority for a fee of $1,000.00.

b. The information panel is typically a white panel of the same size as the system map panel-4'x 4'.

Standard On-Site Identifications Signs (Pictographs)

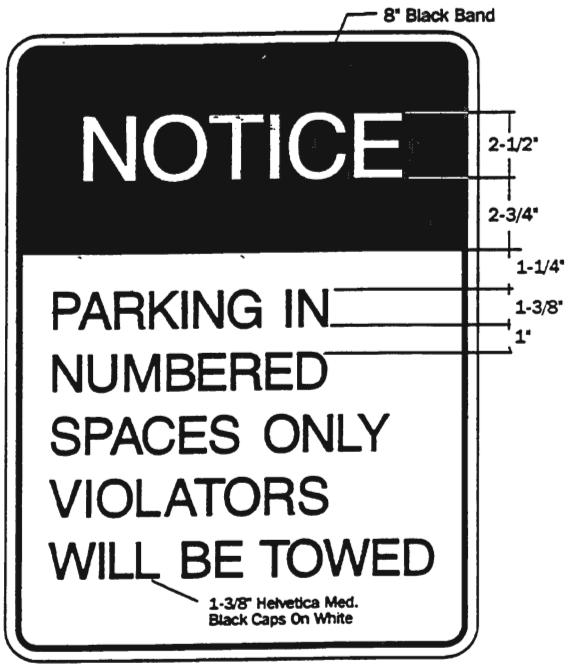






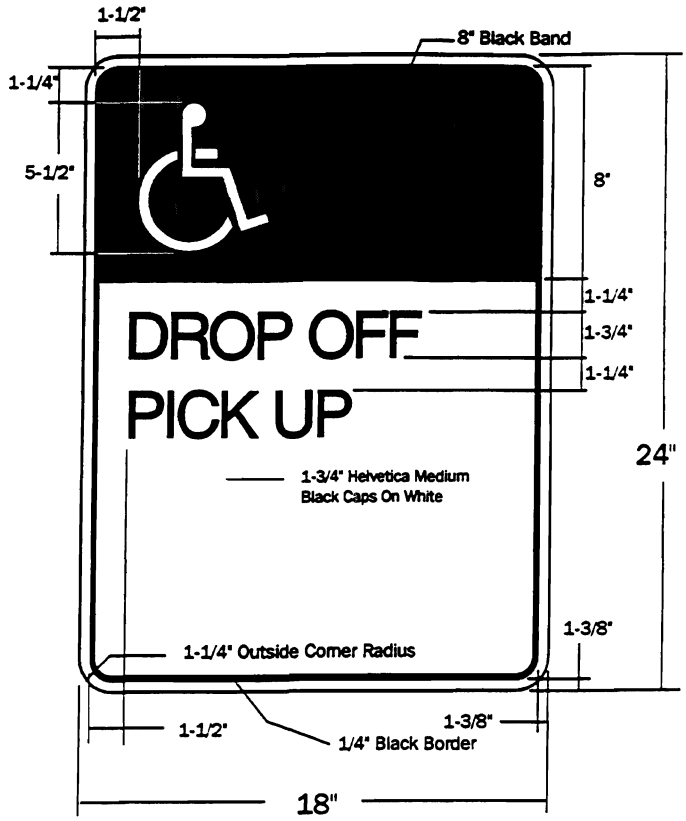
* MBTA to supply art.

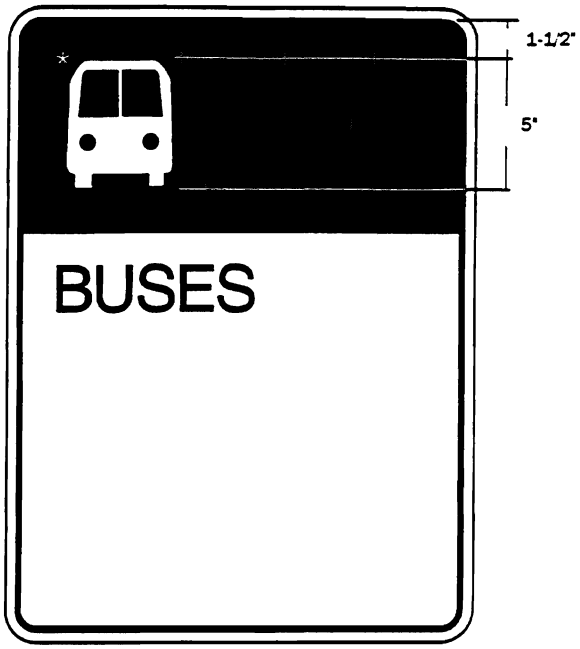
Standard On-Site Identifications Signs (Pictographs)



* MBTA to supply art.

Standard On-Site Identifications Signs (Pictographs)

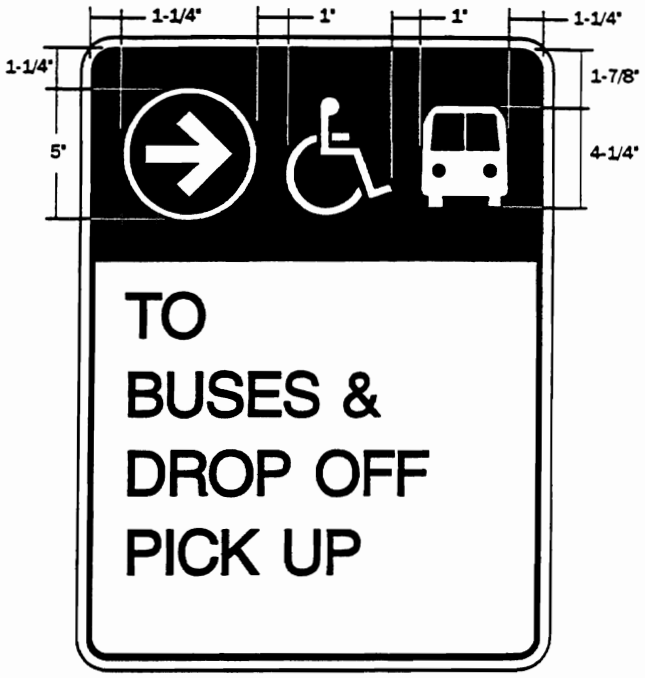




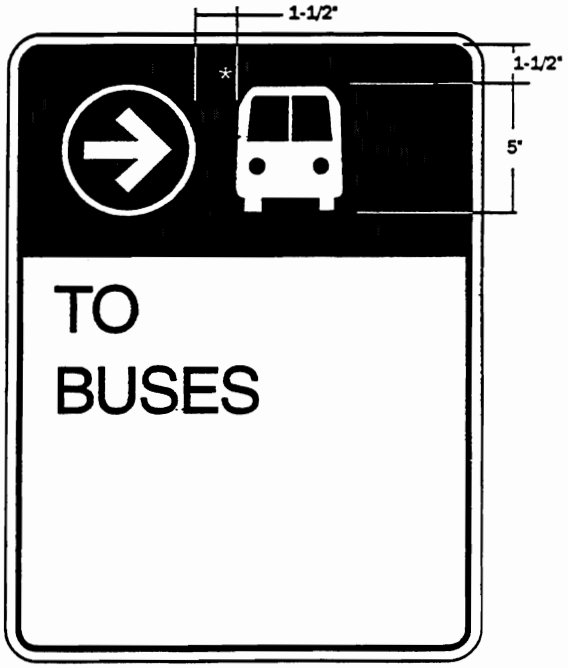
These signs should be located at either end of the bus and drop off/ pick up zones.

* MBTA to supply art.

Examples of On-Site Directional Signs

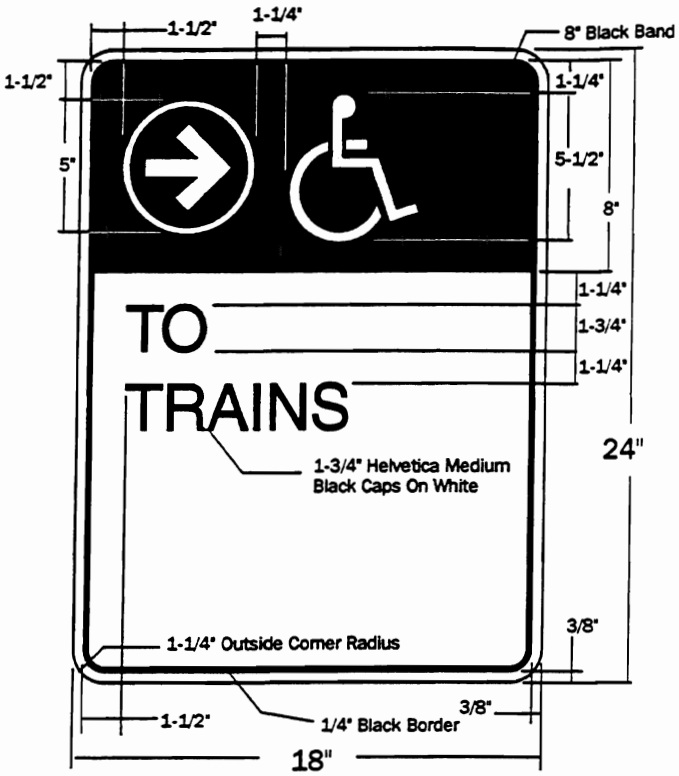


These signs are to used en-route to the various facilities, and up to the platform entrance locations. These signs are not to be used within platform areas.

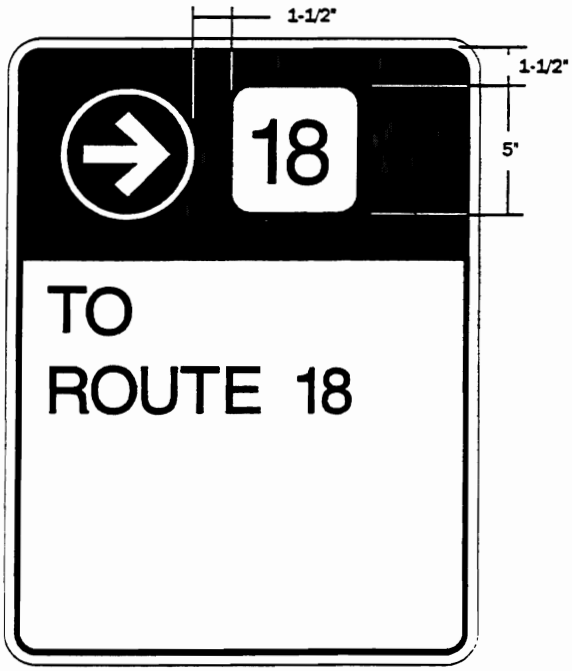


* MBTA to supply art.

Examples of On-Site Directional Signs

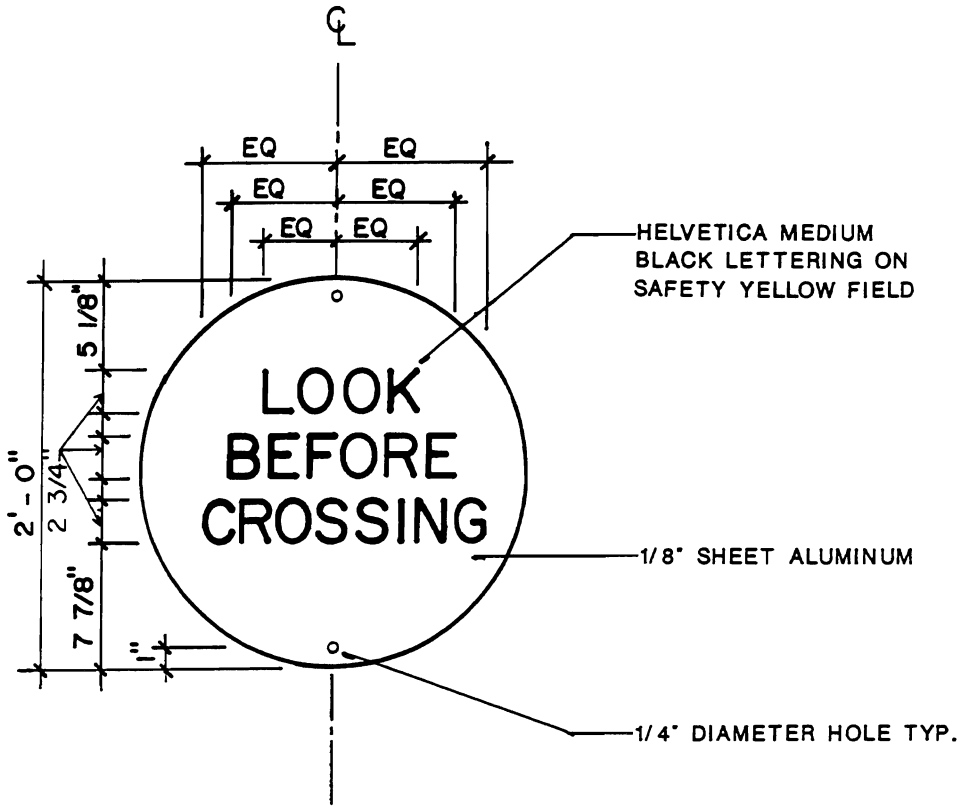


These signs are to be used en-route to the various facilities, and up to the platform entrance locations. These signs are not to be used within platform areas.



* MBTA to supply art.

Standard Vehicular/Pedestrian Track Crossing Sign



G. SIGN MATERIALS AND METHODS OF CONSTRUCTION

1. Fiberglass

   a. All platform and related directional signs, plus the station name sign at the entry to parking lots are 1/4" fiberglass, bonded to 3/4" aluminum channel stiffeners. Refer to "Manual of Guidelines and Standards, Part V" for more detailed information on fiberglass sign material specifications.

   b. The "T" symbol uses 1/4" flat sheet fiberglass over a plywood backing. Trailblazers are 1/8" fiberglass.

   c. All other site miscellaneous small signs are to highway standards- plastic film laminated on 1/8" aluminum.

   d. At locations where the fiberglass sign frame is susceptible to vehicle or snowplow damage, mount the frame on reinforced concrete pedestals, as illustrated in the accompanying detail.

2. Sheet Aluminum

   a. Sheet aluminum of a 0.125" thickness is typically used for all other commuter rail station signs. Typical fabrication and installation details for system identification sign are illustrated on following pages.

   b. The standard mounting detail for all other sheet aluminum sizes is the Massachusetts Department of Public Works P-5 break-away post assembly, specified as galvanized. (See the accompanying detail).

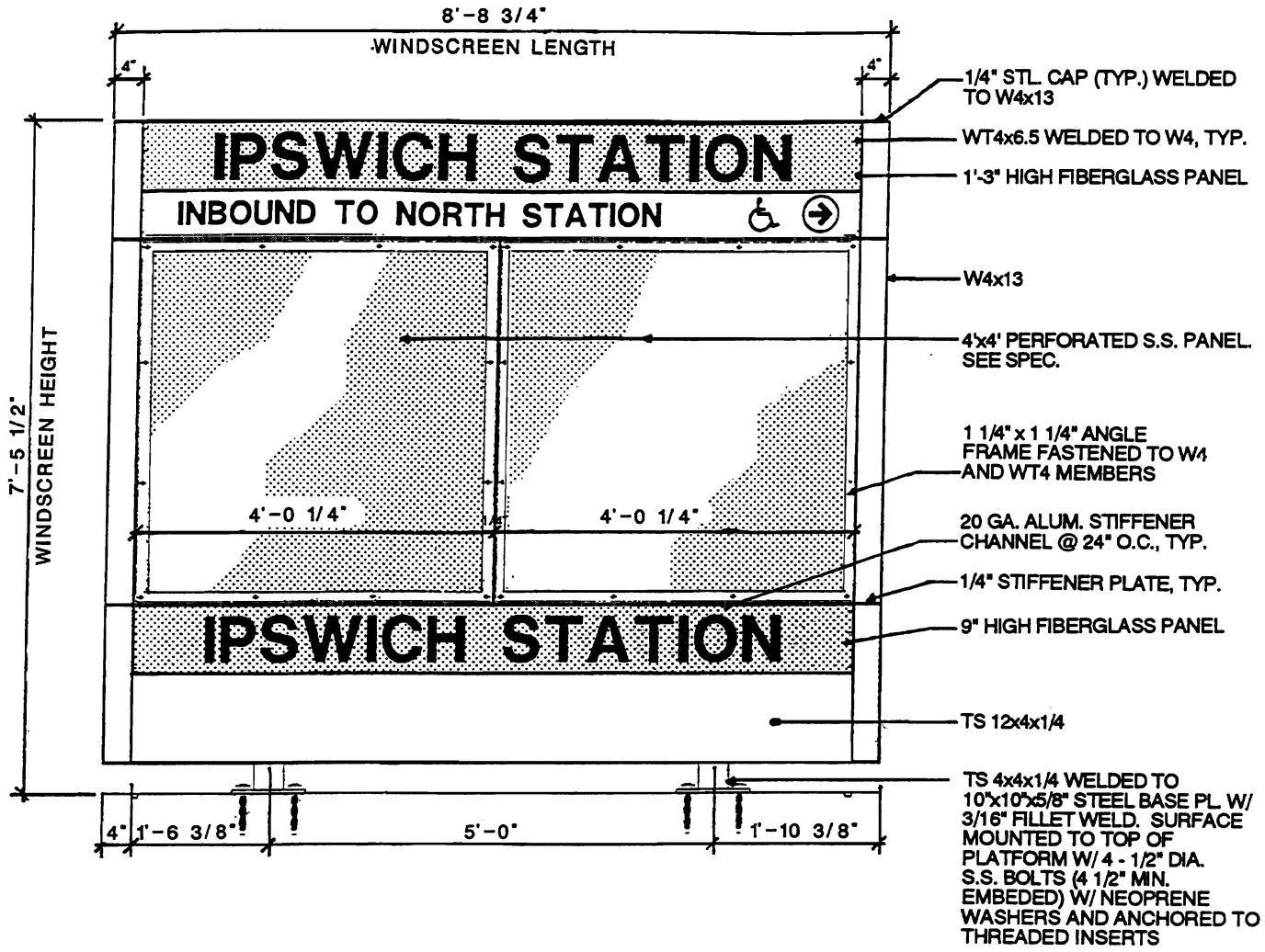
   c. Minimum clearance between the lower face of the circular frame of the system identification sign and grade is 12'-0".

   d. Minimum clearance between all other sheet aluminum signs and grade is 7'-0", a Massachusetts Department of Public Works standard.

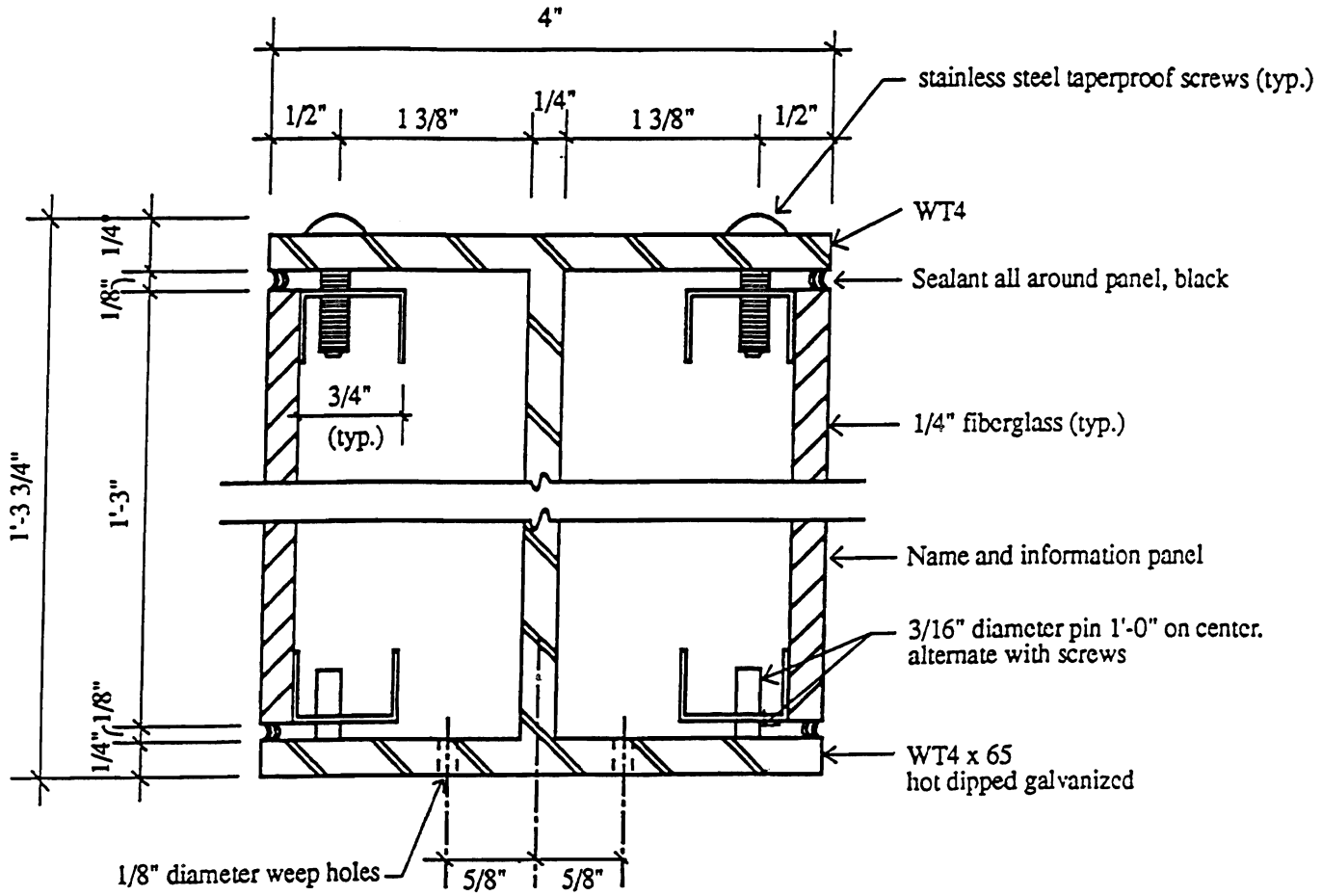
3. Galvanized Steel

   a. Galvanized steel used in sign frames may be finished with shop applied paint within 12 hours of galvanizing.

Typical Construction Details for the Station Identification Sign

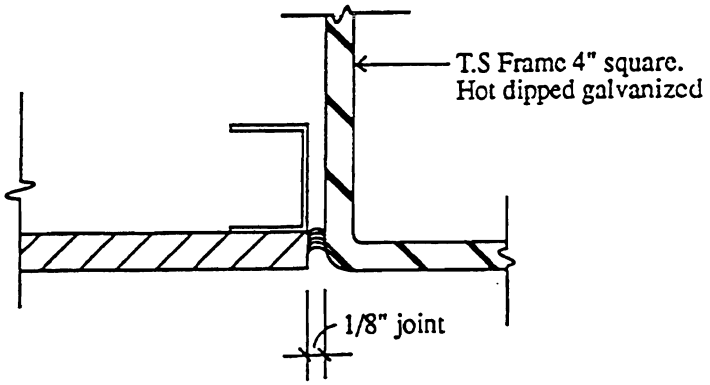


Typical Construction Details for the Station Identification Sign



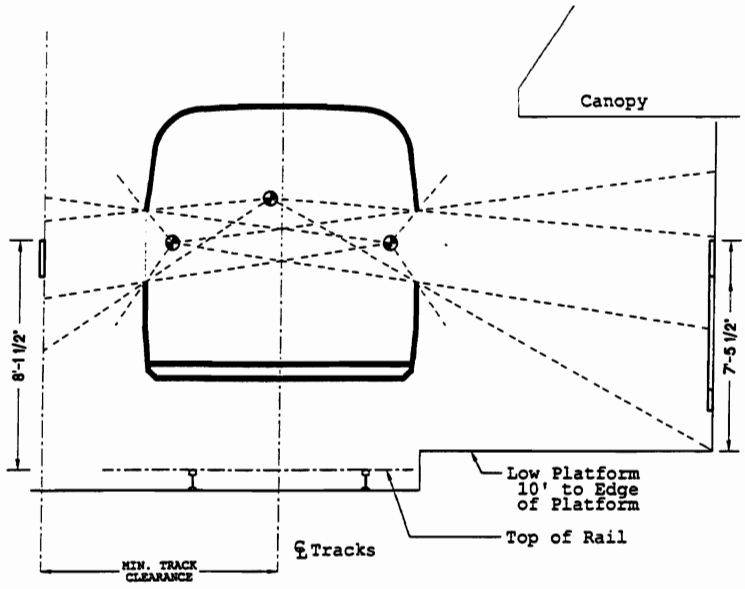
- **Typical Commuter Rail Sign section with Name & Information Band - Fiberglass Sign Panels**

scale: 3/4" = 1"

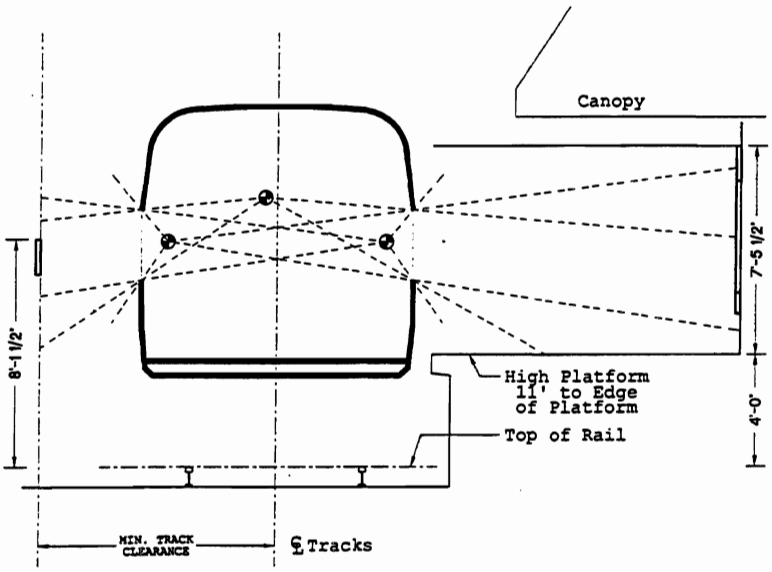


Vertical Joint at Edge of Sign

Station Identification Sign Heights

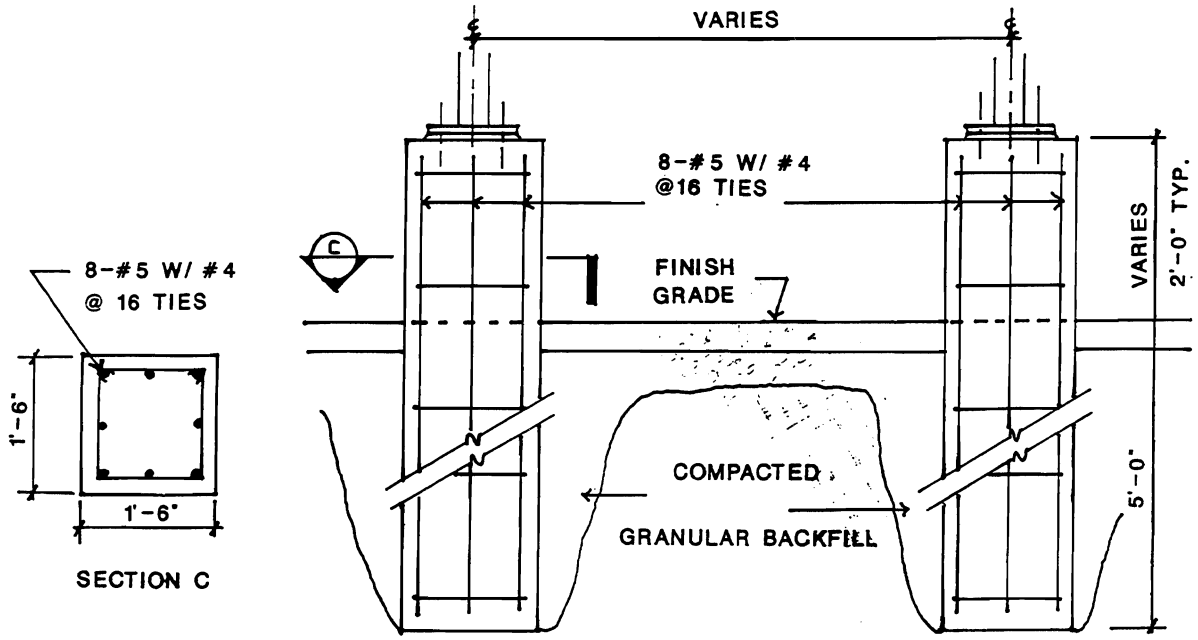


Viewing Angles for Single Height Rail Car at Low Platform

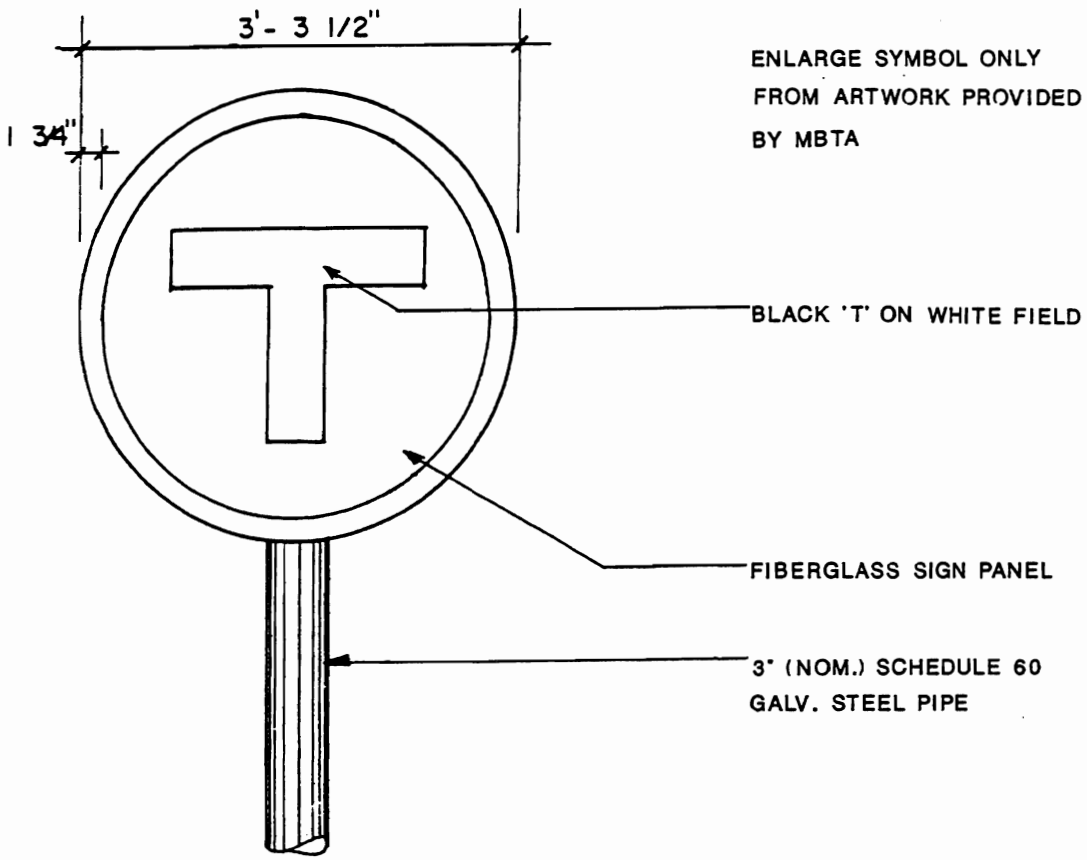


Viewing Angles for Single Height Rail Car at High Platform

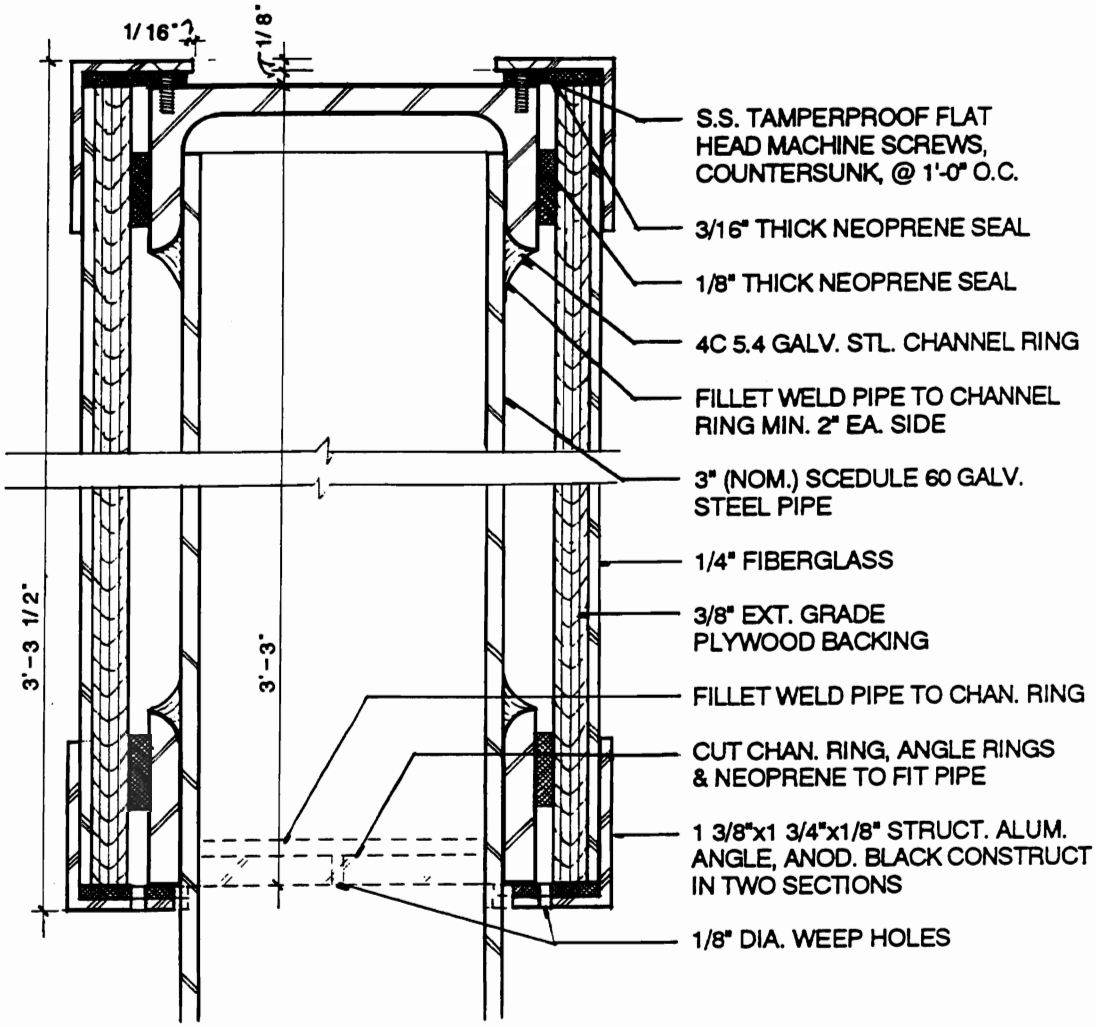
Typical Construction Details for Concrete Pedestals Used with Pedestal- Mounted Station Identification Sign



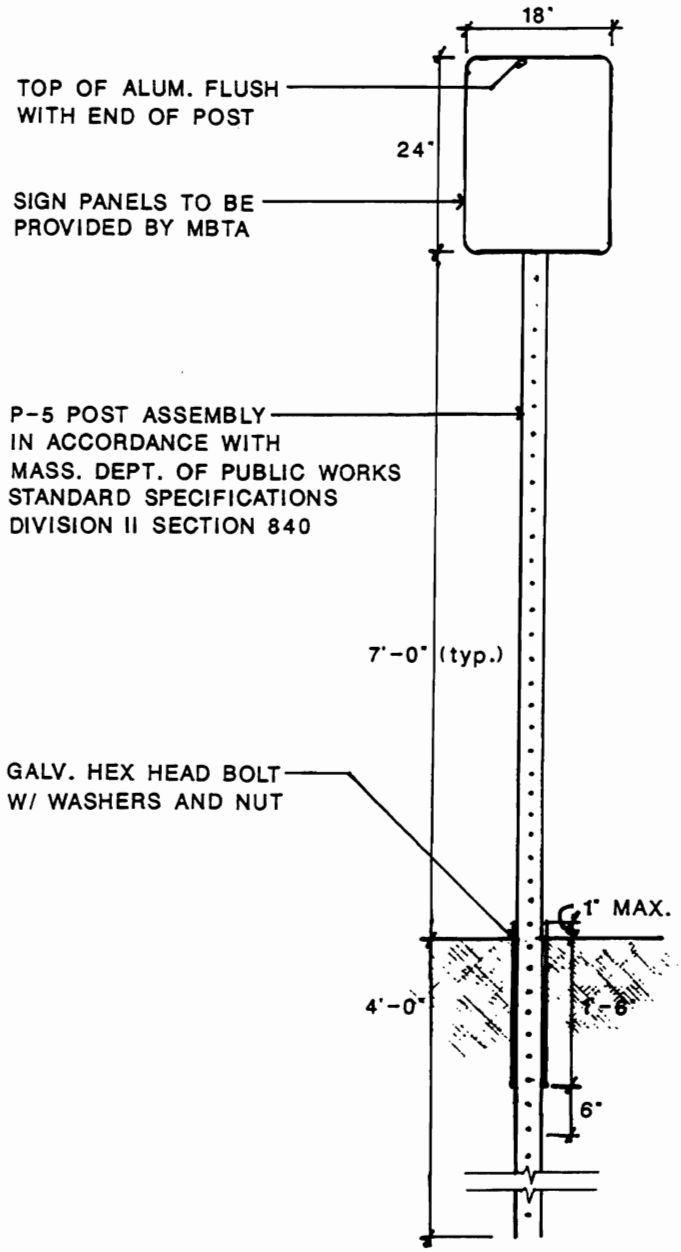
Typical Construction Details for System Identification Sign



Typical Construction Details for System Identification Sign



Standard Mounting Details for Sheet Aluminum Signs



CHAPTER 5
COMFORT AND CONVENIENCE FACILITIES

I. INTRODUCTION

This section deals with the types of user comforts and conveniences that should be incorporated into commuter rail stations, such as seating, telephones, and concessions. These facilities, when integrated into the design, make the station more comfortable and convenient.

II. DESIGN OBJECTIVES

A. COMFORT

Provide facilities that increase the user's comfort while waiting for the train, consistent with the objectives of minimizing targets of vandalism and achieving economy of design.

B. CONVENIENCE

Provide facilities that make the station more convenient to use by consolidating activities that might otherwise require several trips (buying a newspaper, making a phone call, etc.) in one location.

III. DESIGN GUIDELINES

A. GENERAL

Six types of facilities are discussed in this section: seating, telephones, trash receptacles, vending machines and concessions, clocks, and toilet facilities. Some of these facilities should only be included at the most heavily used stations.

At low platform stations with an access platform, platform amenities (seating, etc.) must also be provided on the access platform.

B. SEATING

1. Seating should be provided at all stations and designed to provide maximum:

   - Physical comfort
   - Capacity
   - Freedom of choice
   - Durability under exposure to extreme weather conditions and severe vandalism.

2. Capacity Guidelines

   a. The amount of seating required at a station will vary with the shape and size of the site and surrounding facilities. Seating requirements are best established through observation of how other stations are currently used rather than basing the need on

overall or peak period ridership. The designer should seek to identify the extent to which people use adjacent facilities, such as restaurants, taxi stands, and their cars when waiting for the train.

b. The quantity of seating should also be based on observations of sitting patterns, including the spacing people maintain for psychological comfort. Studies indicate that typically 28 people are seated per 100 linear feet of sitting space.

3. Location Guidelines

a. Seating should be located where the user will have easy and direct access to the platform. The user should also have a direct view of approaching trains from the seating.

b. Avoid locating seating across the tracks from sign units to discourage vandals from throwing objects at the signs while sitting at the station.

c. Seating should be highly visible from surrounding activities and in a well lighted area for night time use.

d. Avoid locating seating in areas that will impede pedestrian traffic flow.

e. Seating should be in a covered location if possible.

f. Do not locate seating where it may prevent direct approach to signs by users with limited vision.

g. Seating must conform to AAB requirements to be located at intervals along platforms to not exceed 200 feet.

C. TELEPHONES

1. A public telephone should be readily accessible at all commuter rail stations, either on site or immediately adjacent to the site.

2. Telephones should be located:

- Under shelter or cover where possible
- In highly visible (from the station and surrounding area) and heavily traveled areas
- Where users can view an approaching train
- Where they do not impede or obstruct pedestrian traffic
- In areas and at mounting heights accessible to the handicapped

3. Where interior public or banks of (two or more in a single location) telephones are provided, at least one should be TTY equipped. It must be identified with the TTY symbol.

D. TRASH RECEPTACLES

1. Trash receptacles should be installed at all commuter rail stations, but only if the Authority has negotiated an agreement for the periodic pick-up of trash and maintenance of the receptacles.

2. The receptacles should be located:

   - In heavily used areas
   - Where they do not impede pedestrian traffic
   - At points that are accessible to pick-up crews

E. VENDING MACHINES AND CONCESSIONS

1. Currently, the Authority does not install or maintain vending machines or concessions at commuter rail stations. In certain instances, the Authority encourages businesses to lease unused space and provide concessions oriented to users of the system. The following guidelines identify some of the more appropriate types of vending machine services and concessions that might be provided at commuter rail stations, as well as the appropriate locations for these facilities.

2. The types of vending machine services that are most appropriate at a station include:

Newspapers	Snacks-candy, pastries, etc.
Soda	Coffee
Stamps	

   With the exception of newspapers, these vending services are generally provided in an enclosed building and are under continuous surveillance by the operator or user of the services. Some of the services also require electricity, plumbing, and heat. Accordingly, vending services other than newspapers should be provided only at those stations with enclosed buildings and that are manned by a ticket agent or a concessionaire.

3. Among the concessions appropriate to a commuter rail station are:

Diners and restaurants	Florist shops
Taxi stands	Real estate offices
Gift shops	Travel agencies
Book stores	Laundry/dry cleaners

   Concessions such as these will require an enclosed building. They are generally feasible only when the station has high ridership or is located in an area that has high visibility and traffic volumes.

4. The need for vending machines and concessions should be evaluated on the basis of the availability of these facilities in the vicinity of the station.

5. Vending machines and concessions should be located in areas that are:

   - Readily accessible to waiting areas and pedestrian walkways along an accessible route.
   - Easily observed by the station agent (in the case of most vending machine services) or from the surrounding community (in the case of newspaper vending machines.)

6. The facilities should also be located where they do not obstruct views of the platform and approaching trains or impede pedestrian flow.

F. CLOCKS

Clocks should be provided at all stations with enclosed waiting areas. They should be located where they are readily visible from all parts of the waiting area and conform to ADA standards.

G. TOILET FACILITIES

1. All manned stations shall have toilet facilities, and at the discretion of the station agent, may be made available to commuter rail passengers. All toilet facilities must comply with the Americans with Disabilities Act Accessibility Guidelines. Toilet facilities open to the public must also comply with the Rules and Regulations of the Architectural Access Board of the Commonwealth of Massachusetts.

2. Toilet facilities shall conform to all building code requirements. Fixtures and accessories required include:

1 sink	1 tissue dispenser
1 toilet	1 trash receptacle
1 mirror with shelf	grab bars as required
1 electrical outlet	partitions as required
1 soap dispenser	

3. The preferred location for toilet rooms in station buildings is adjacent to the main waiting room with access doors directly observable from the agent's office.

IV. DESIGN CRITERIA AND DETAILS

A. SEATING

1. Seating at a station can take many forms, but should meet the following dimensional criteria:

   - A continuous bench style, at least 7'-6" long, to allow for maximum freedom of choice.
   - A minimum of 16" and maximum of 20" high
   - A minimum of 15" in depth
   - A minimum 3" heel space for ease of rising from a seated position.
   - To facilitate sitting and rising for people with limited strength and flexibility it is recommended that at least half of the fixed benches at each site have a high back and armrests.

2. The seating should be designed to require a minimum number of vertical supports, thereby reducing the potential for litter collection beneath the seating.

3. Seats should be slatted and sloped from front to back for rain and snow drainage.

4. Seating materials must be highly durable and vandal-resistant, but non abrasive to human contact.

5. Avoid the use of materials such as the extruded aluminum benches found in prefabricated bus shelters and wood of 2" nominal thickness or smaller since they are highly susceptible to vandal damage.

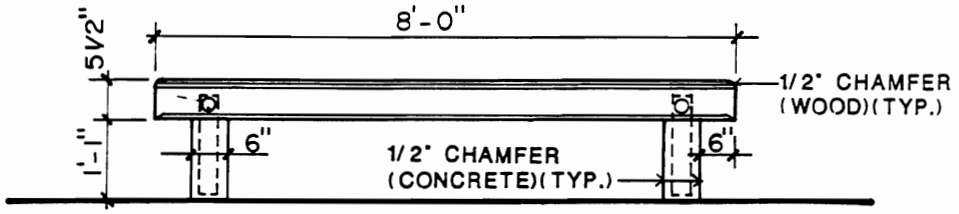
B. TELEPHONES

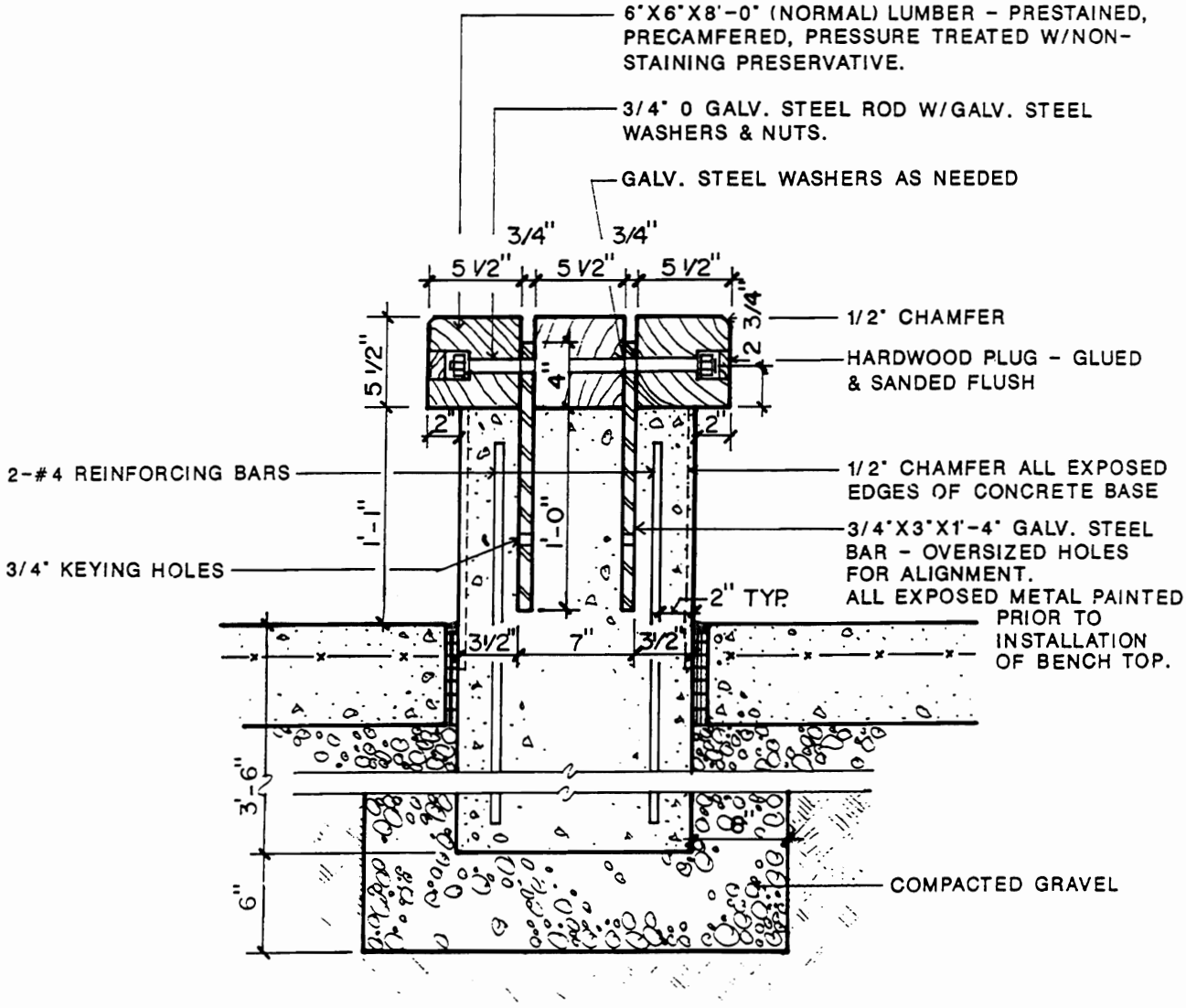
1. Public telephone installations must include at least one telephone per bank (two or more in a single location) that is accessible to people who use wheelchairs, as required by the Rules and Regulations of the AAB and ADAAG. In addition, 25% of the telephones per bank, but never less than one, must have a volume control.

2. Among the other features which each telephone installation should contain are:

   - Posted numbers listing emergency numbers (police, fire, etc.) and convenience numbers (Authority number for information on service, delays, etc., and local taxis).
   - A telephone directory, attached to the installation and protected from the weather.
   - Lighting to read the dial and directory.
   - A shelf for personal articles such as gloves, purse, change, etc.
   - TTY

Typical Bench Construction Details





C. TRASH RECEPTACLES

1. Trash receptacles should follow the MBTA Commuter Rail standard with locking tops. Refer to previous construction jobs for specifications. They should also have the following features:

   - Large opening for easy trash disposal
   - Minimal exposure of opening to rain and wind
   - High (55 gallon) capacity, self-draining container
   - Durable material, resistant to the abuse of weather and vandalism
   - Capability for being affixed to an object such as a utility pole or located within a heavy, immovable container (precast concrete, etc.)

D. TOILET FACILITIES

1. Fixtures: all urinals, and sinks shall be wall-hung vitreous china. Fittings should be either stainless steel or chrome-plated brass with concealed or vandal-proof anchors.

2. Accessories: compartment partitions and fittings should be stainless steel. Mirrors should be plate glass with stainless steel frames. All other accessories should be of stainless steel construction with concealed and tamper-proof mounting devices.

3. Room finishes: should be rugged, chemical- resistant, and easily cleaned.

4. Lighting: provide lighting to achieve an average level of 30 foot-candles. Switch should be provided so that the lights are in operation only when the facilities are in use.

5. Ventilation: provide mechanical ventilation to the outdoors with make-up air supply from either louvers or undercuts at the toilet room access doors.

6. Floor drains and wash down facilities should be included where possible.

CHAPTER 6
LANDSCAPING

I. INTRODUCTION

This section deals with landscaping of the station site. As used in this manual, the term landscaping refers to the existing natural features of a station, as well as additional natural (trees, shrubs, ground cover, etc.) and man-made (fencing, special paving materials, etc.) elements that can be used to enhance the overall visual quality of a station. Proper use of existing station landscaping, when combined with the selective use of new landscape elements, can also help make the site compatible with the surrounding area.

II. DESIGN OBJECTIVES

The principal objectives of the site landscaping are increased attractiveness, user safety and security, preservation of significant existing features, durability/maintainability of the landscape elements, and soil conservation.

A. ATTRACTIVENESS

Provide an attractive station environment by using landscaping to 'soften' the effect of large paved areas, integrate the station into compatible surrounding areas, and buffer the station from incompatible surroundings.

B. SAFETY AND SECURITY

Use landscaping elements to improve the safety of pedestrian and vehicular movements and to maximize surveillance of the station (and enhance user security) from the surrounding area. Note that enhancing security through increased station visibility from the surrounding area may conflict with requirements to buffer the site from incompatible surroundings.

C. PRESERVATION

Preserve and capitalize on existing site assets such as trees, water, views, or historic buildings.

D. DURABILITY/ MAINTAINABILITY

Use landscaping suited to the climate, resistant to vandalism, and low in maintenance requirements.

E. SOIL CONSERVATION

Provide adequate storm water drainage facilities that minimize uncontrolled water run-off and minimize soil erosion on and off site.

III. DESIGN GUIDELINES

A. GENERAL

Three areas of concern addressed in this section are: buffers, site drainage and planting. Site improvements in each of these categories may contribute to the achievement of the attractiveness, safety, security, preservation, and soil conservation objectives. All of the design guidelines pertaining to each of the categories are aimed at satisfying the fifth objective-durability and maintainability of the site improvements.

B. BUFFERS

1. Buffers include various types of natural and man-made devices that can be used to visually screen incompatible land uses (such as a station parking lot from adjacent residences) or to attenuate the noise emanating from trains.

2. Among the visual screening devices that may be used are:

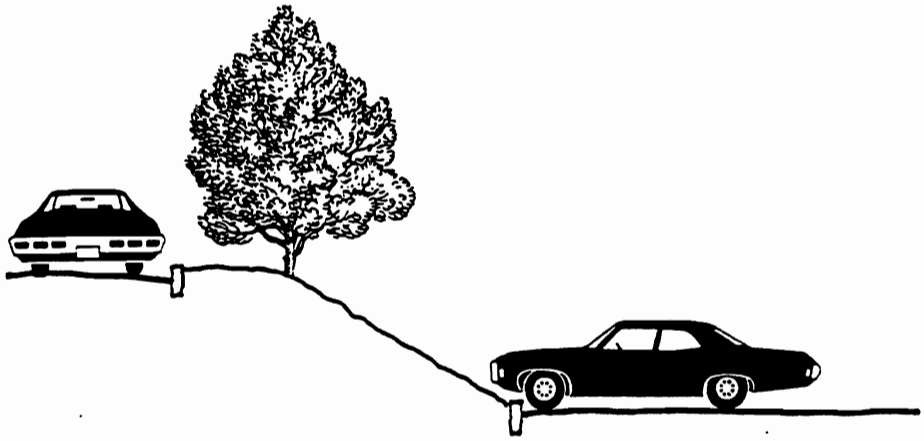
   a. Site topography: at some stations it may be possible to use substantial grade changes on the site to visually screen parking from the surrounding area. However, it is necessary to maintain the visibility of the parking lot at all times, in order to increase the feeling of security and discourage vandalism and crime.

   b. Earth berms: where a relatively level site does not permit the use of site topography, earth berms, as illustrated on the following page, may be used as a screening device. They are generally a minimum of 3'-0" high and require a minimum of 20'-0" horizontal distance to achieve proper slope ratios for the minimum height berm. They are typically planted with a low maintenance ground cover, described later in this section.

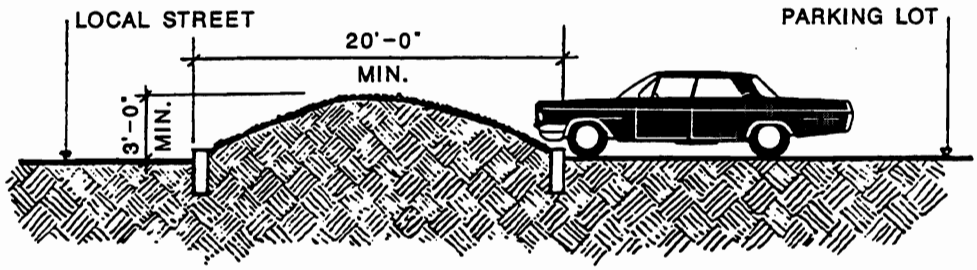
   c. Planting: sticker-bushes, hedgerows, and trees may be used as a partial visual screen. The general effect of planting will be to lessen the visual impact of the station on the adjacent area, rather than to create a complete blockage of sight lines between the station and the surrounding area. Maintaining at least partial station visibility from the surrounding area is important to enhancing personal security at the station. Appropriate plant materials are described later in this section.

   d. Fencing: another means of visual screening is accomplished through the use of fencing. Opaque fencing material - solid wood fencing and masonry walls are examples - is typically very expensive and difficult to maintain. Consequently, the use of fencing as a screening device is not recommended at commuter rail stations and should be used only when the other three approaches are found to be unsuitable to a site.

Site Topography as a Screening Device



Berms as a Screening Device



3. The Federal Environmental Protection Agency has formulated standards for the noise levels of railroad rolling stock. The proposed standards are 88dBA for rolling stock operating at up to a 72 kph (45 mph) and 93 dBA for speeds greater than 72 mph, as measured at a distance of 30 meters (100'-0").

4. Two approaches to alleviating noise impacts are described below:

   a. Berms and walls: a high percentage of rail right-of -way noise is generated at track level. Earth berms or walls located immediately adjacent to the tracks will partially deflect or absorb this noise and reduce noise levels on abutting properties.

   b. Visual screening: in some instances it has been noted that a major component of the noise problem is the result of a psychological rather than a physiological reaction to the noise- i.e., viewing the source of the noise becomes a disproportionately large part of the problem. In these cases, it may be possible to mitigate the impact through the use of densely planted shrubs and trees, especially evergreens. Note, however, that these materials do little to alleviate the noise.

5. Location Guidelines

   a. The location of visual screening devices will, of course, vary with the site. In general, however, they should be located at the perimeter of the site.

   b. Maintain a 10'-0" distance between walkways, platforms, and parking areas and new or existing dense vegetation.

   c. Locate buffers in a manner that insures undisturbed visibility at all pedestrian and vehicular intersections.

   d. Select tree species whose lowest branch height is 7'-0" or greater.

   e. Insure that the landscaping does not reduce the effectiveness of the site lighting.

   f. Avoid screening the platform waiting areas from the surrounding neighborhood and streets.

C. SITE DRAINAGE

1. As used in this chapter of the manual, the term site drainage refers to actions required to manage storm water in both paved and unpaved areas of a station site. Stations should have storm drainage systems that connect to municipal systems. Much of the storm water flows to existing street catch basins or is simply absorbed by the soil on-site. All plans for upgrading a station drainage system must be coordinated with local public works departments and conservation commissions.

2. Station improvements, especially parking, create a substantial increase in paved area and may also disrupt natural drainage patterns. The following guidelines establish a preferred approach to dealing with the issues of grade modifications, drainage of paved areas and unpaved areas, and slope control.

3. Grade Modification Guidelines

   a. The grading design should balance the aesthetic, drainage, maintenance, and operational needs of the station site.

   b. Coordinate proposed grades with plant material to remain (such as larger trees) and with other existing site elements.

   c. The grading design should attempt to balance cut and fill.

   d. Design slopes within minimum and maximum tolerances to insure positive drainage, ease of maintenance, and prevention of erosion.

   e. Grading Around Trees to be Preserved

      - The maximum fill allowed within the drip line of any tree (the area encompassed by the tree's longest branches) shall be 6". No cut shall be permitted within the drip line area.

      - When more than 6" of fill is required, the tree should be removed. In the case of significant specimens, protect with a terrace or drywell.

      - Provide positive drainage away from the base of all trees.

4. Drainage of Paved Areas

   a. In general, all new or rehabilitated parking lots at commuter rail stations should have a storm drainage system connecting with an existing municipal system.

   b. Minimum and maximum slopes in paved areas will vary with the material and location, but should be as prescribed in the Circulation and Parking sections of this manual.

c. Design flows for the system should be determined by using the Rational Method (or an accepted alternative) and as detailed in Manual No. 37, Design and Construction of Sanitary and Storm Sewers, American Society of Civil Engineers.

d. The selection of a particular storm frequency and discharge capacity should be based upon the need for maximum reliability of operation, consistent with economy and local experience. The following chart can be used as a guide in determining the storm frequency.

Storm Frequency in Years	Drainage System Element
5	Secondary ditches
10	Median ditches, gutters, ditch inlets, curb and paved area inlets, and inlet ponding
25	All pipes and culverts except under major roads and culvert outlets
50	Relocated stream channels, major stream structures, transverse pipes, culverts, etc. under major roads
100	Use only when required by the local agency

e. Hydraulics: in the design of a storm drain system, the following factors should be considered:

- Topography: avoid designs that require pumping
- Economy of construction: avoid excessively deep cuts
- Peak flows
- Slopes: determine slopes required for proper self-cleaning at minimum flows
- Minimum pipe size: 12 inches
- Maximum velocity: up to 10 feet per second
- Hydraulic design should be in accordance with manual No. 37, Design and Construction of Sanitary and Storm Sewers, American society of Civil Engineers. Coefficients of roughness should be as recommended in that manual.

f. Gravity Flow: provide a self-cleaning velocity of 2 feet per second. Where this minimum is impractical to obtain, the design should consider the effects of sedimentation, odors, and operational difficulties at lower velocities.

g. Water Collection

- As illustrated in the diagram, continuous sheet flow of water into a swale located along an edge of flat areas,

followed by the collection of this water in several area drains, is desirable. Area drains connected by ridges and valleys break up the continuity of paved surfaces and should be avoided.

- If area drains must be used, avoid strong linear paving patterns and reduce the pitch of the paving to the minimum.
- Trench drains are very expensive and should only be used where the collection of water in a small number of area drams is not practical, such as at the foot of some stairs and ramps.
- Coordinate the site drainage pattern with the design of barriers and curbs. For example, at some locations water from paved areas may flow to adjacent unpaved areas and be absorbed by the soil. In this situation, guard rail or bollards should be used instead of curbing as a barrier system at the edge of paved areas to prevent vehicles from destroying vegetation in the unpaved area.
- Coordinate drainage of the site with drainage of the track and roadbed to insure that water from one does not cause problems with the other.
- Where the presence of salt is likely, do not pitch the pavement to flush or recess planting areas.
- Avoid sheet flow across walks, ramps, and stairs.

5. Drainage of Unpaved Areas

a. Unpaved or planted areas should be designed to absorb normal rainfall without draining onto paved areas. In areas with steep, planted slopes, horizontal run outs should be incorporated into the design to absorb the water run-off before it reaches a paved area.

b. The range of acceptable natural slopes in unpaved areas is presented in the following chart.

Type of Ground Cover	Maximum Slope	Desirable Maximum Slope	Minimum Slope	Desirable Slope
Mowed Lawn	3:1	4:1	1%	2%
Unmowed Lawn and Ground Cover Areas	3:1 (if jute mat used)	3:1 (Fill slope) 2:1 (cut slope)	2%	3%

D. PLANTING

1. The use of plant materials at commuter rail stations is one of the most effective means of enhancing the visual quality of a station, while at the same time performing an essential soil conservation function.

2. An important consideration in a station improvement program is the preservation of significant existing natural features- trees, shrubs, etc. By capitalizing on these features, new planting costs can often be kept to a minimum and concerned abutters may be reassured that the physical character of the site will not change dramatically. Among the actions that should be taken to preserve existing natural features are:

   a. Wherever grading requires a cut of more than 6" or a fill of more than 4" at sites with good topsoil, the topsoil should be stripped and stored for later use.

   b. Care should be taken in the scheduling and techniques of earth moving operations to insure that erosion of soil does not take place. Slopes that must remain unplanted or unfinished for substantial periods should have their soils stabilized with mulches, fast-growing temporary ground covers (rye, grass, or buckwheat) or man-made soil stabilizers (such as jute mats).

   c. In areas that are to be cleared and grubbed, an analysis of all trees 2" and larger in diameter should be performed. Where possible, sound specimens of either soft or hardwood trees should be identified. They should be thinned to a minimum of 10'-0" on center and tagged for preservation. Exceptions to the thinning may be natural clumps of trees such as birches.

3. Types of Planting

a. Public areas in general and transit stations in particular can be difficult environments for the growth of plant material. Abuse by vandals, intense exposure to both vehicular and pedestrian traffic, and minimal maintenance all contribute to the condition.

b. The list of recommended plant materials (on the following page), developed by the American Horticultural Society in the report Transit Planting: A Manual, accounts for these problems. The report's criteria for selection are:

- Climatic zone suitability
- Durability (including pollution resistance)
- All year performance
- Long life span
- Low-cost maintenance
- Artistic utilization and availability

c. This list is not necessarily a definitive list for all planting that may be used at stations. Most of the materials were chosen for durability in urban locations or proximity to parking or roads. Many of the Authority's commuter rail stations are in suburban or rural areas without the major impact of vehicular and city pollution. Many of these stations have fine specimens of indigenous plant material. Consequently, the designer should also consider plantings that have already proven their suitability for a particular site.

d. Plant materials should require little care other than initial planting and cultivation. Grass should not be used except in those cases where the Authority enters into agreements with municipal or commercial establishments to provide maintenance, or where the appearance of uncut grass is not objectionable. Bushes and shrubs should not require trimming or pruning. Fruit bearing trees should also be avoided.

4. Location of Planting

a. Planting materials can reinforce the pedestrian circulation, but for the most part, cannot control it. Careful planning of access points to the site and platform area will help insure that planting areas do not become "short cut" paths.

Recommended Plant Materials

TREES

Acer platanoides	(Norway Maple)
Acer rubrum	(Red Maple
Amelanchier candensis	(Serviceberry)
Carpinus betulus	(European Hornbean)
Cornus mas	(Cornelian Cherry)
Fraxinus pennsylvanica	(Green Ash)
Ginko biloba	(Ginkgo)
Halesia carolina	(Carolina Silverbell
Ilex opaca	(American Holly)
Koelreuteria paniculata	(Goldenrain-tree)
Liquidambar styraciflua	(Sweet-Gum)
Phellodendron amurense	(Amur Cork-tree)
Pyrus calleryana 'Bradford'	(Bradford Pear)
Quercus phellos	(Willow Oak)
Sophora japonica	(Japanese Pagoda-tree)
Tilia cordata	(Littleleaf-Linden)

SHRUBS

Abelia grandiflora	(Glossy Abelia)
Acanthopanax sieboldianus	(Aralia)
Berberis thunbergil	(Japanese Barberry)
Buxus microphylla var. japonica	(Japanese Boxwood)
Chioanthus virginicus	(Fringe-tree)
Deutzia gracilis	(Slender Deutzia)
Elaeagnus angustifolia	(Russian Olive)
Forsythia x intermedia	(Forsythia)
Ilex crenata	(Japanese Holly)
Juniperus chinensis "Pfitzerianas"	(Pfitzer Juniper)
Kolkwitzia amabilis	(Beautybush)
Rhus copallina	(Shining Sumac)
Spiraea x vanhouttei	(Vanhouette Spirea)
Taxus cuspidata	(Japanese Yew)
Xanthorhiza simplicissima	(Yellowroot)

GROUND COVERS

Ajuga reptans	(Bugleweed)
Arctostaphylas uva-ursi	(Bearberry)
Cotoneaster horizontalis	(Rockspray Cotoneaster)
Epimedium sp.	(Forsythia)
Hedera helix	(English Ivy)
Hemerocallis sp.	(Daylily)
Ilex crenata	(Japanese Holly)
Juniper chinensis 'Pfitzerianas'	(Pfitzer Juniper)
Lonicera japonica	(Japanese Honeysuckle)
Rosa wichuraiana	(Memorial Rose)
Sedum acre	(Goldmoss Stonecrop)
Vinca minor	(Periwinkle)

b. Shrubs should be planted so that when mature, they will not overhang walkways or platform areas.

c. Trees that overhang walkways and waiting areas should be of a species whose lower limbs are of sufficient height to allow comfortable pedestrian circulation.

d. In general, trees should be clustered in designated areas of a parking lot rather than scattered throughout the lot. In all cases, trees planted adjacent to parking areas should be carefully protected with bollards or curbs.

e. Where traffic islands or planted strips are located within parking areas, plant materials should be selected with snow removal in mind. Plants should also not grow high enough to obstruct motorist's view. The planting must be able to bear the weight of accumulated snow, and trees should be planted a minimum of 8'-0" from the curb edge where snow would be deposited by plows, and small bushes should be avoided. In general, only low, hardy ground covers, grass, or non-plant ground covers should be used. Do not locate trees or other plant materials at random throughout a parking area because of these snow problems and the loss of space that can be used for parking. Concentrate planting in a few areas with a high visual impact.

f. Non-Plant Ground Covers

- Fabric weed barriers: Used before ground covers are applied. It is also used to keep mulch on sloped areas from sliding down.

- Small stones or gravel: Also used as a ground cover.

- Mulch: There are two general categories of mulch. Grass mulch consists of salt marsh hay or straw and is applied using an asphaltic binder, which holds the soil together until the seed is established. This mulch may also be used as a temporary soil erosion measure during construction. Bedding mulch is used to keep down weeds and to retain surface moisture around trees and shrubs. It also provides an attractive uniform ground plane surface. Three types of bedding mulch may be used:

- Wood chips from local sources are usually the cheapest form of mulch and provide a coarse, light-gray appearance. Wood chips vary greatly in quality.
- Pine bark mulch provides a darker, more uniform color and has a fine texture. It tends not to stay in place on sloping surfaces.
- Fir chunk bark mulch is the most expensive mulch, but it provides excellent uniform color and texture. Larger dimension and weight gives it a longer life span than the other mulches.

IV. DESIGN CRITERIA AND DETAILS

A. GENERAL

Design criteria are described in this section for site drainage and planting. Since the design of these items tends to be site specific, only general criteria are presented below.

B. SITE DRAINAGE

1. Materials

   a. General Guidelines: the selection of the type of pipe to be utilized should be governed by the following factors:

      - Permanency of the facility
      - Static and impact loads which the pipe must sustain
      - Physical and chemical characteristics of soil
      - Physical and chemical characteristics of fluids
      - Availability of materials and the relative economics of construction of the installation
      - Initial cost versus maintenance cost of the system

   b. All materials and installation methods shall conform with the Commonwealth of Massachusetts Department of Public Works Standard Specifications for Highways and Bridges.

2. Storm Drainage Pipe

   a. Materials and structural requirements shall be detailed in Manual No. 37, Design and Construction of Sanitary and Storm Sewers, American Society of Civil Engineers.

   b. Class shall be as required for strength.

   c. Acceptable types of pipe are cast iron, reinforced concrete (both circular and elliptical), asbestos-coated corrugated metal. Where the base metal of the corrugated pipe is steel, it shall be galvanized.

3. Manholes, Basins, and Inlets

   a. Provide manholes at maximum intervals of 300'-0" for drains 48" or smaller, and 600'-0" for drains 54" and larger. Minimum inside diameter shall be 4'-0". Minimum wall thickness shall be as required for depth of structure, but in no case less than 5".

   b. Provide manholes at every junction, change in alignment, or change in grade of all drains.

   c. All collection structures shall be self-cleaning and draining. Do not use cushions because of insect and odor problems.

d. Each culvert or drain 15" or more in diameter shall be provided with a secured, but removable bar screen at the inlet and outlet structure to prevent children from crawling into the pipe. To reduce clogging of the inlet screen, use sloped vertical bars so that debris will ride up the bars during flow.

e. All structures other than inlets shall be provided with steps meeting OSHA requirements. Minimum access opening shall be 22".

f. Drainage inlets in curbed roadways shall be curb type inlets.

g. Provide wing walls at inlets and outlets to improve flow. Energy dissipaters, flared ends, and erosion protection such as rip rap, gabion walls, or paved aprons should be utilized where flows can be expected to scour down-stream channels.

h. All grates, covers, and lids shall be cast iron with no primer or coatings. All inlet grates located in roadways and walkways should be designed to avoid trapping bicycles.

C. PLANTING

1. The American Horticultural Society, in the report referenced earlier in this subsection, identifies five types of plant material and three areas of a station in which plantings might be used.

2. Plant Types
   a. Large trees: deciduous trees which reach the most monumental proportions, are long lived, and are suitable for planting as space definers and shade producers.

   b. Small trees: deciduous flowering trees which, at mature height and branching structure, are most likely to conflict with space required for pedestrians unless they are sited properly.

   c. Evergreen trees: coniferous evergreen forest species with a large mature height.

   d. Shrubs: deciduous or evergreen, broadleaf or coniferous, which are adaptable to local conditions and retain their form without pruning.

   e. Ground cover: typical are the evergreen perennials with a dwarfed or prostrate condition and which are adaptable to local conditions.

Plant Material Usage

Description/Usage		Large Trees	Small Trees	Evergreen Trees	Shrubs	Ground Covers
Mature height[1]		75'- 0" or greater	25'- 35'	50'- 0"	20'- 0"[2]	24"
Mature spread[1]		50'- 0" or greater	20'- 35'	35'- 0"	15'- 0"	Up to 6'- 0"
Station Entry Zone	Minimum size at planting	4"- 5" caliper	3"- 3 1/12" caliper	NA	3'- 5' height 3'- 5' spread	2-year plants or 24" spread
	Minimum branch height	7'- 0"	4'- 6"	NA	NA	NA
General Circulation	Minimum size at planting	3"- 3 1/2" caliper	NA	NA	3'- 0" height 3'- 0" spread	2-year plants or 20" spread
	Minimum branch height	6 - 0"	NA	NA	NA	NA
Peripheral Areas	Minimum size at planting	3"- 3 1/2" caliper	2"- 2 1/2" caliper	3"- 3 1/2" caliper	3'- 0" height 3'- 0" spread	2-year plants or 20" spread
	Minimum branch height	5'- 0"	3'- 0"	NA	NA	NA
Minimum spacing (massing and screening)		20'- 0" o.c.[3]	10'- 0" o.c.	10'- 0" o.c.	2 1/2'- 3' o.c.	12" o.c. or 24" o.c.
Minimum spacing (in circulation spaces)		25'- 0" o.c.	NA	NA	2 1/2'- 3' o.c.	12" o.c.
Maximum spacing (in circulation spaces)		45'- 0" o.c.	NA	NA	5'- 0" o.c.	24" o.c.

1 Mature height and spread as listed in Trees for American Gardens and Shrubs for American Gardens by Donald Wyman. While it is understood that in urban conditions plants do not reach their normal mature heights and spread, the dimensions listed in this table shall be used in conjunction with the height and spread dimensions listed in Wyman's books for the purpose of specie selection.

2 5'- 0" in station entry zone.

3 On center.

3. Station Areas for Planting

   a. Station entry zone: the area adjacent to primary access street, including the main vehicular and pedestrian access and drop-off area(s).

   b. General circulation: all secondary pedestrian access routes, including plantings within parking areas and adjacent to platforms.

   c. Peripheral Areas: areas not used by pedestrians or vehicles that either need general ground covers or that provide the opportunity to screen the station from the surrounding community.

4. The matrix on the preceding page identifies the preferred size and location of each type of planting in each station area.

5. Planting Requirements

   a. Existing topsoil at each location should be examined to determine suitability for use in planting areas. Acceptable topsoil is defined as a friable loam, neither heavy in clay nor light in sand, containing a minimum of 3% organic matter and having an acidity range of (pH) 5.5 to 7.5. If the soil is found unsuitable, it shall either be improved to an acceptable state or removed from the planting area and replaced with a new soil meeting these criteria.

   b. Soil of good fertility and friability shall be provided for the top 6" of lawn areas, the top 12" in shrub and perennial beds, and in a zone of 12" around the root balls of all trees, as illustrated on following pages.

   c. Planting should be designed to survive without any supplemental irrigation after the first year.

   d. Grasses may be either mowed or un-mowed. Mowed grasses used near circulation areas should be of a high quality perennial seed mix suitable to the locality and site conditions. Un-mowed grasses should be coarser grasses and may have non-grass flower species mixed in.

   e. Sod may be used to establish grass areas where economics dictate or when it is desirable to use seed mixes not available as sod. When sod is applied on slopes greater than 4:1, use jute matting. All seeded areas should be mulched.

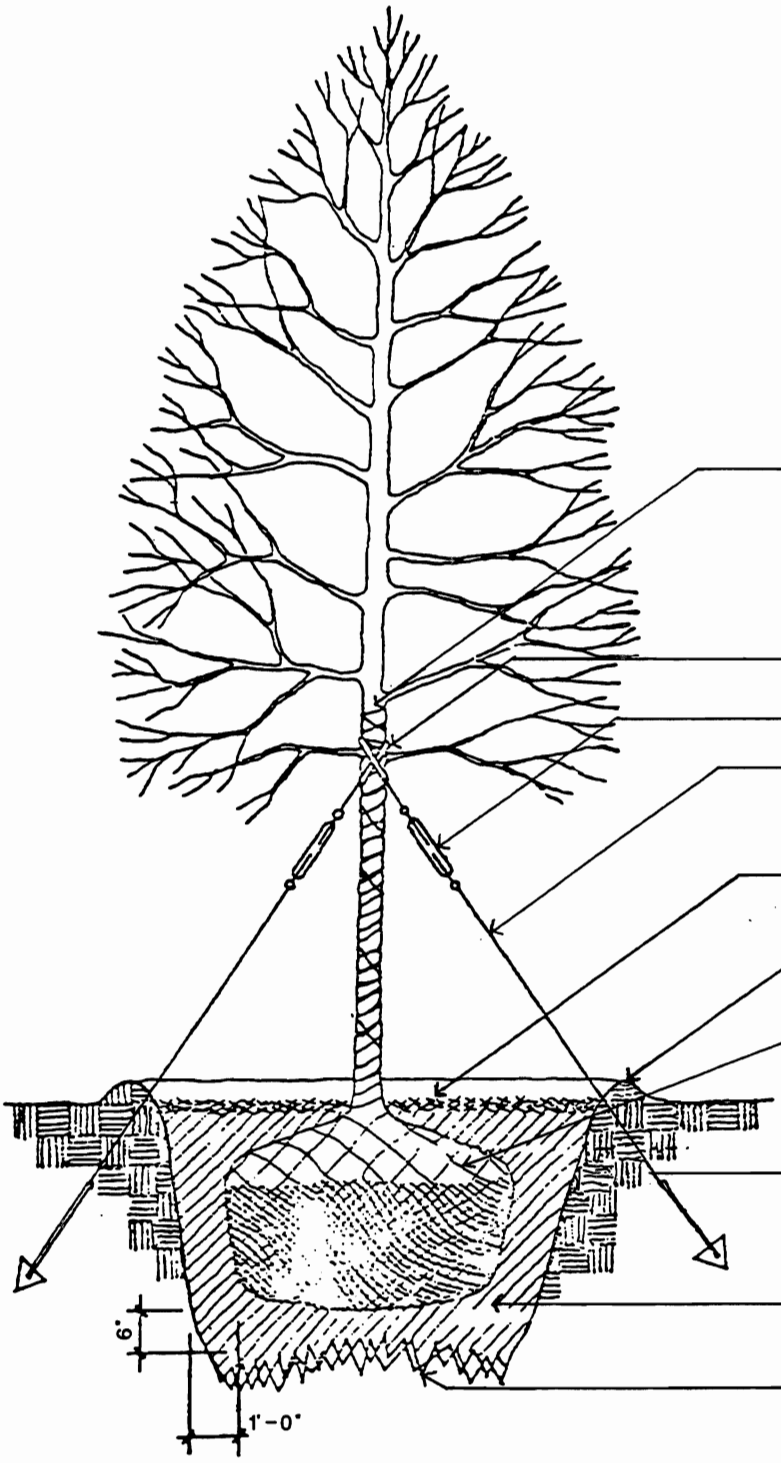
f. Broadleaf ground cover and bedding plants should be planted using 2" peat pots and spaced 12" to 18" apart in each direction. Coniferous ground covers should be containerized plants with a minimum of an 18" to 24" spread and planted between 2'-0" and 3'-0" apart. All beds for ground cover and bedding plants should be covered with 3" of bark mulch.

g. Do not use plant material of a type, or in a location, where it will spread into the track area and foul the ballast and drainage. Chemicals that kill vegetation are often used along the track right-of-way to eliminate unwanted plant material.

6. Tree Grates

All tree grates shall be cast iron with no primers or coatings. They should be round or square, such as those illustrated on the following pages.

Typical Tree Planting Detail in Unpaved Area



REMOVE ENOUGH WHOLE BRANCHES (NOT JUST END TIPS) TO REDUCE FOLIAGE BY 1/3. NEVER LEAVE "V" CROCHES OR DOUBLE LEADERS. RETAIN NORMAL PLANT SHAPE.

ALL PRUNING MUST BE DONE AFTER PLANTING.

TREE SHALL BEAR SAME RELATIONSHIP TO GRADE AS IT DID TO PREVIOUS GRADE.

WRAP ENTIRE SURFACE OF TRUNK TO HEIGHT OF SECOND BRANCHES, TIE SECURELY AT TOP AND AT 24" INTERVALS VERTICALLY

REINFORCED RUBBER HOSE

12" GALVANIZED TURNBUCKLE

7 STRAND (1/4") GALVANIZED WIRE ROPE GUY, 3 PER TREE

3" LAYER WOOD CHIP MULCH

4" HIGH EARTH EDGE TO FORM SAUCER

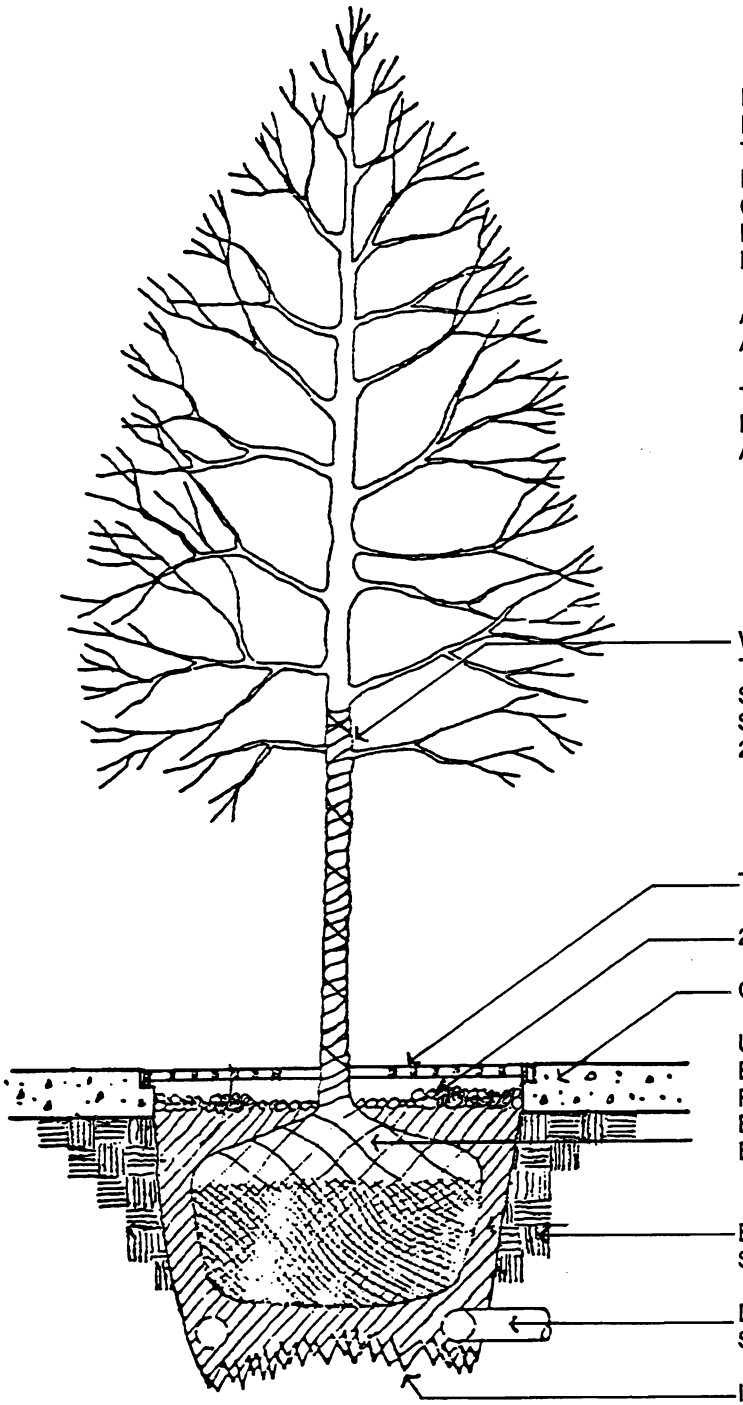
UNTIE ALL CORDS BINDING BURLAP TO TRUNK AND FOLD DOWN TO 1/3 OF BURLAP AROUND ROOT BALL

30" STEEL LAWN GROUND ANCHOR - 3 PER TREE OR APPROVED EQUAL

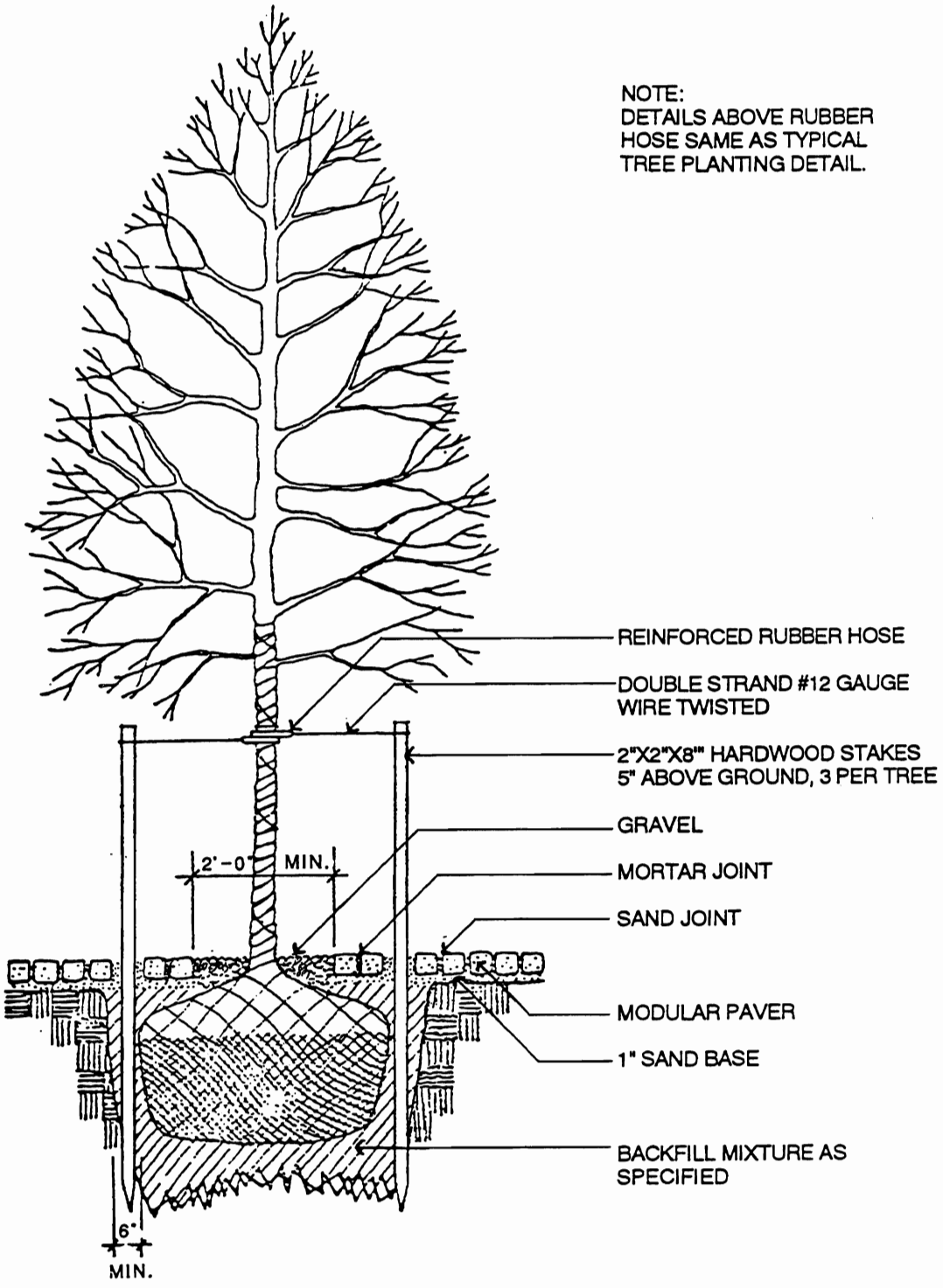
BACKFILL MIXTURE AS SPECIFIED

IN SOIL CONDITION WHERE CLAY CONTENT EXCEED 50% LOOSEN EARTH IN BOTTOM OF TREE PIT BEFORE ADDING BACKFILL

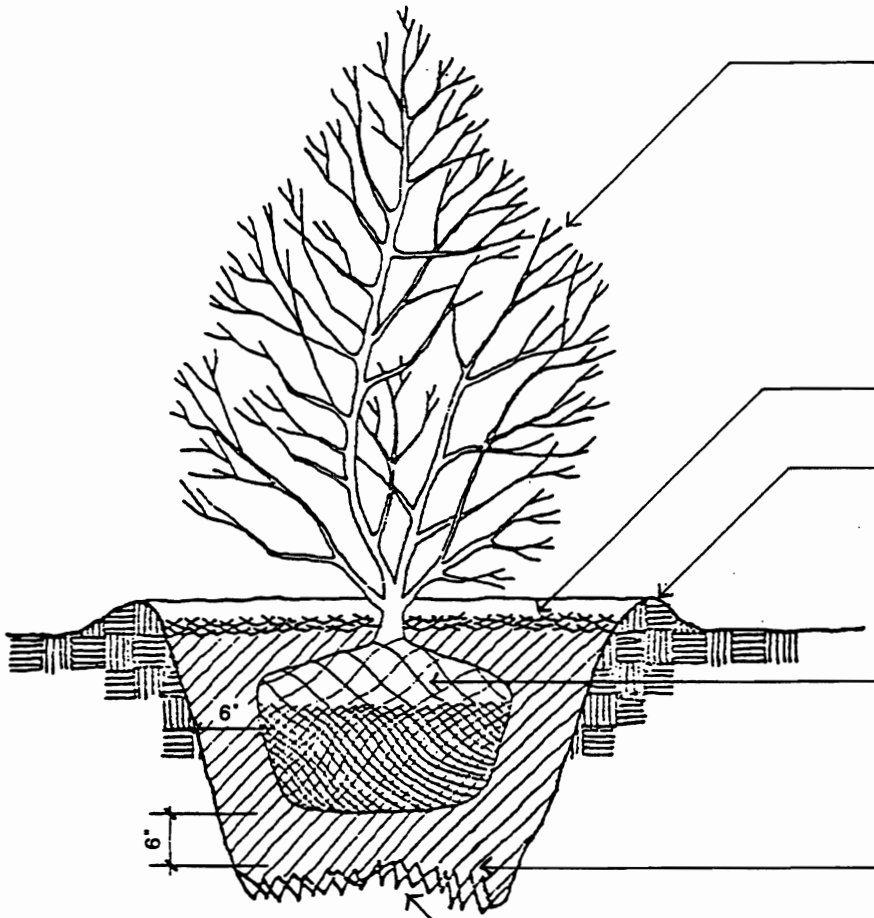
Typical Planting Detail Using Tree Grate



Typical Tree Planting Detail in Area of Modular Paving, Such as Granite Block



Typical Shrub Planting Detail



ALL PRUNING MUST BE DONE AFTER PLANTING

SHRUB SHALL BEAR SAME RELATIONSHIP TO GRADE AS IT DID TO PREVIOUS GRADE.

REMOVE ENOUGH WHOLE BRANCHES (NOT JUST END TIPS) TO REDUCE FOLIAGE BY 1/3. NEVER LEAVE "V" CROCHES OR DOUBLE LEADERS. RETAIN NORMAL PLANT SHAPE.

3" LAYER WOOD CHIP MULCH

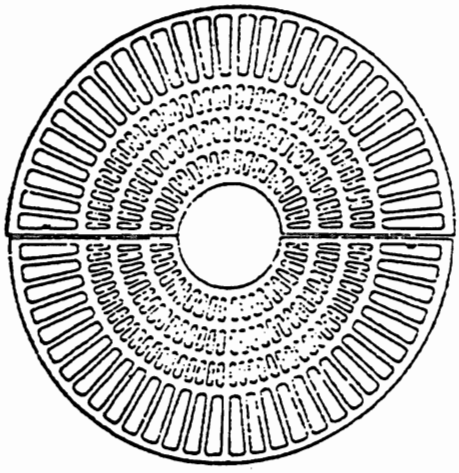
4" HIGH EARTH EDGE TO FORM SAUCER

UNTIE ALL CORDS BINDING BURLAP TO TRUNK AND FOLD DOWN TO 1/3 OF BURLAP AROUND ROOT BALL

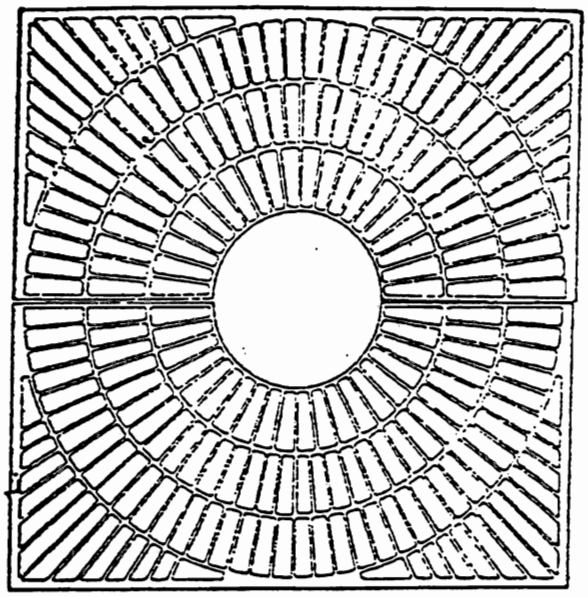
BACKFILL MIXTURE AS SPECIFIED

IN SOIL CONDITION WHERE CLAY CONTENT EXCEED 50% LOOSEN EARTH IN BOTTOM OF TREE PIT BEFORE ADDING BACKFILL

Typical Tree Grates and Installation Detail



180° ROUND
PREFERRED FOR CONCRETE,
ASPHALT OR MODULAR PAVING
WITHOUT A STRONG PATTERN



180° SQUARE
PREFERRED FOR MODULAR
PAVING WITH A STRONG
RECTILINEAR PATTERN